

Standard Specifications for Road and Bridge Construction

Adopted January 1, 2012

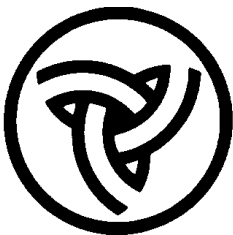


Illinois Department of Transportation

Standard Specifications for Road and Bridge Construction

Adopted January 1, 2012

Price: \$35.00



**Illinois Department
of Transportation**



Illinois Department of Transportation

Departmental Policies

D&E-2

Effective Date: May 25, 2011

STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION

1. **POLICY.** Road and bridge construction shall be performed according to the standards set forth in this policy.
2. **PURPOSE.** The purpose of this policy is to provide for the publication of a book prescribing the Standard Specifications for Road and Bridge Construction.
3. **GUIDELINES FOR IMPLEMENTATION.** The book outlines the general requirements and covenants applicable to all highway construction improvements as well as provisions relating to materials, equipment, and construction requirements for individual items of work (as defined in the book) on road and bridge construction projects awarded by the department.

The book provides detailed requirements on such subjects as:

- a. General Requirements and Covenants
 - b. Earthwork, Landscaping, Erosion Control
 - c. Subgrades, Subbases, and Base Courses
 - d. Surface Courses, Pavements, Rehabilitation, and Shoulders
 - e. Structures
 - f. Incidental Construction
 - g. Work Zone Traffic Control and Protection, Signing, and Pavement Marking
 - h. Electrical Requirements
 - i. Materials
 - j. Equipment
4. **RESPONSIBILITIES.** The Division of Highways and its Regional Offices shall implement the standards published in the book accompanying this policy.
 5. **ACCESSIBILITY.** Electronic versions of this policy and the specifications book are located at the Policy & Research Center site on InsideDOT, the department's internal website. Printed copies of this policy may be obtained by contacting the Bureau of Design and Environment. Printed versions of the specifications book may be obtained from the Bureau of Business Services' Policy Distribution Office.

CLOSING NOTICE. Supersedes: Departmental Policy D&E-2, Standard Specifications for Road and Bridge Construction, Effective: May 11, 2006.

Approved:

Director of Highways

Date

Preface

While editing this version of the Standard Specifications, an effort was made to continue the elimination of three unnecessary phrases from the book. The removal of these phrases should not be construed as a change in the Department's intent or use of these Specifications but rather as a wholesale attempt to return the book to its proper format.

- 1) "which price shall include...". This phrase was commonly used within Basis of Payment articles to further clarify what was to be included in the unit price bid for that item of work. The term "work" is defined in Article 101.55 as "...all labor, materials, tools, equipment, and other incidentals necessary..." and thus all aspects of the work are by definition included in the unit price bid unless specified to be paid for separately.
- 2) "to the satisfaction of the Engineer". This phrase was commonly used throughout the book to emphasize the authority of the Engineer. Article 105.01 covers this fact sufficiently.
- 3) "at the Contractor's expense". This phrase was used throughout the book to clarify who is responsible for ongoing work, non-conforming work, damage, negligence, etc. These situations are sufficiently covered in such Articles as 104.01, 105.03, 106.02, 107.20, 107.30, etc. Where the phrase was deemed appropriate, it was usually changed to "at no additional cost to the Department".

Revision Marks. Information which has been changed from the 2007 Standard Specifications is generally noted with vertical lines in the outside margin. These lines are intended to facilitate the location of new material, but provide no guarantee, explicit or implicit, that text not highlighted has appeared in prior editions of the Standard Specifications.

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DIVISION 100. GENERAL REQUIREMENTS AND COVENANTS**SECTION 101. DEFINITION OF TERMS**

Wherever in these Specifications or in other contract documents the following terms or pronouns in place of them are used, the intent and meaning shall be interpreted as follows.

101.01 Abbreviations. Wherever the following abbreviations are used in these Specifications or on the plans, they are to be construed the same as the respective expressions represented.

AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
ADAAG	Americans with Disabilities Act Accessibility Guidelines
AISC	American Institute of Steel Construction
ANLA	American Nursery and Landscape Association
ANSI	American National Standards Institute
ARA	American Railway Association
AREMA	American Railway Engineering and Maintenance of Way Association
ASA	American Standards Association
ASLA	American Society of Landscape Architects
ASTM	ASTM International
AWG	American Wire Gauge
AWPA	American Wood Preservers Association
AWS	American Welding Society
AWWA	American Water Works Association
BWC	Bridge Welding Code
CRSI	Concrete Reinforcing Steel Institute
EPA	United States Environmental Protection Agency
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
FSS	Federal Specifications and Standards
GSA	General Services Administration
ICEA	Insulated Cable Engineers Association
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IEMA	Illinois Emergency Management Agency
IEPA	Illinois Environmental Protection Agency
IES	Illuminating Engineering Society
IMSA	International Municipal Signal Association
ISO	Insurance Services Organization
ITE	Institute of Transportation Engineers
MASH	AASHTO Manual for Assessing Safety Hardware
MUTCD	Illinois Manual on Uniform Traffic Control Devices
NACE	National Association of Corrosion Engineers
NCHRP	National Cooperative Highway Research Program
NEC	National Electrical Code

NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NRMCA	National Ready-Mix Concrete Association
OSHA	Occupational Safety and Health Administration
SAE	Society of Automotive Engineers
SSPC	Society for Protective Coatings
UL	Underwriters Laboratories
USASI	United States of America Standards Institute
USDA	United States Department of Agriculture

101.02 Advertisement. The public announcement, as required by law, inviting bids for work to be performed or materials to be furnished.

101.03 Award. The decision of the Department in the form of a letter of intent to accept the proposal of the lowest responsible bidder for the work, subject to the approval and execution of a satisfactory contract by the Department, receipt of a bond to secure the performance thereof, and compliance with such other conditions as may be specified or otherwise required by law.

101.04 Bidder. Any individual, firm, partnership, or corporation submitting a proposal for the work contemplated, acting directly or through a duly authorized representative.

101.05 Bridge. A structure, including supports, erected over a depression or an obstruction, such as water, highway, or railroad, and having a track or passageway for carrying traffic or other moving loads, and having a length of more than 20 ft (6.1 m).

Length. The length of a bridge structure is the overall length measured along the line of survey stationing back to back of backwalls of abutments, if present, otherwise end to end of the bridge floor; but in no case less than the total clear opening of the structure. The length of multiple box culverts shall be between the extreme ends of the openings.

Roadway width. The clear width measured at right angles to the longitudinal centerline of the bridge between the bottom of curbs or guard timbers, or in the case of multiple heights of curbs, between the bottoms of the lower risers.

101.06 Calendar Day. Every day shown on the calendar.

101.07 Cataclysmic Event. An occurrence, caused exclusively by any of the irresistible forces of nature that is an unexpected, singular event without continued, persistent existence or that is irregularly predictable. The event must occur without the involvement of human causative action, and must not be preventable or capable of substantial limitation in its impact by application of human care, skill, or foresight. Cataclysmic events include earthquakes, floods, flash floods of surface water caused by heavy rains and runoff water, tornadoes, or other cataclysmic phenomena of nature. A flood, defined as water elevation in excess of the channel capacity of a river, stream, or other body of water is not a cataclysmic event, unless the flood water elevation exceeds the 100-year flood elevation as defined in the contract.

101.08 Chief, Bureau of Construction. The Engineer in charge of the Central Bureau of Construction in Springfield.

101.09 Contract. The written Agreement between the Department and the Contractor setting forth the obligations of the parties thereunder, including, but not limited to, the performance of the work, the furnishing of labor and materials, and the basis of payment.

The contract includes the invitation for bids, proposal, letter of award, contract form and contract bond, Specifications, Supplemental Specifications, Special Provisions, general and detailed plans, and any Agreements required to complete the construction of the work in an acceptable manner, including authorized extensions thereof, all of which constitute one instrument.

101.10 Contract Bond. The approved form of security furnished by the Contractor and his/her surety as a guaranty that the Contractor will execute the work according to the terms of the contract.

101.11 Contract Time. The number of working days, calendar days, or combination allowed for completion of the contract, including authorized time extensions.

When a calendar date of completion is shown in the proposal, the contract shall be completed on or before that date.

101.12 Contractor. The individual, firm, partnership, joint venture, or corporation contracting with the Department for performance of prescribed work.

101.13 Culvert. A drainage structure extending across and beneath a traveled way and having a tubular or box type cross section.

101.14 Department. The Department of Transportation of the State of Illinois with principal offices of business at Springfield, when the State is the awarding authority.

The County Board, when a County is the awarding authority.

The Council, the City Council, or the President and Board of Trustees, when a city, village, or town is the awarding authority.

The County or Municipality and the Illinois Department of Transportation when the Illinois Department of Transportation is the awarding agency and the County or Municipality is supervising construction.

101.15 Reserved.

101.16 Engineer. The Chief Engineer/Director of Highways of the Department of Transportation of the State of Illinois; or authorized representative limited by the particular duties entrusted to that person, when the State is the awarding authority.

The County Superintendent of Highways or the County Engineer, when the county is the awarding authority. The County Superintendent of Highways or the County Engineer, and the Chief Engineer/Director of Highways of the Illinois Department of Transportation when the Illinois Department of Transportation is the awarding authority and the County is supervising construction.

The City Engineer or Engineer employed by the Municipality, when a city, village, or town is the awarding agency. The City Engineer or Engineer employed by the Municipality, and the Chief Engineer/Director of Highways of the Illinois Department of Transportation when the Illinois Department of Transportation is the awarding agency and a city, village, or town is supervising construction.

101.17 Equipment. All machinery and equipment, together with the necessary supplies for upkeep and maintenance, and also tools and apparatus necessary for the proper construction and acceptable completion of the work.

101.18 Extra Work. An item of work not provided for in the contract as awarded but found essential and germane to the satisfactory completion of the contract within its intended scope as determined by the Engineer.

101.19 Inspector. The authorized representative of the Engineer assigned to make detailed inspection of any or all portions of the work or material.

101.20 Invitation for Bids. The advertisement for proposals for all work or materials on which bids are required. Such advertisement will indicate with reasonable accuracy the quantity and location of the work to be done or the character and quantity of the material to be furnished and the time and place of the opening of proposals.

101.21 Laboratory. The testing laboratory of the Department or any other testing laboratory which may be designated by the Engineer.

101.22 Local Traffic. Local traffic is traffic whose immediate destination is within the limits of construction or closure, limited to use by persons for necessary access to real property not otherwise accessible by another public way.

101.23 Materials. Any substances specified for use in the construction of the project and its appurtenances.

101.24 Median. The portion of a divided highway separating the traveled ways for traffic in opposite directions.

101.25 Reserved.

101.26 Pavement Structures. The combination of subbase, base course, and surface course placed on a subgrade to support the traffic load and distribute it to the roadbed.

101.27 Pay Item. A specifically described unit of work for which a price is provided in the contract.

101.28 Plans. The contract drawings, or exact reproductions thereof, that show the location, character, dimensions, and details of the work to be done. Contract drawings include, but are not limited to, the approved plans, profiles, typical cross sections, detail drawings, working drawings, supplemental drawings, and Highway Standards.

101.29 Proposal. The offer of a bidder, on the prescribed form, to perform the work and to furnish the labor and materials at the prices quoted.

101.30 Proposal Guaranty. The security furnished with a bid to guarantee the bidder will enter into the contract if the bid is accepted.

101.31 Railroad. The Railroad or Railway Company whose property is involved in the work.

101.32 Railroad Engineer. The Chief Engineer or Superintendent of the Railroad, or authorized representative limited by the particular duties entrusted to him/her.

101.33 Regional Engineer. The Licensed Professional Engineer in complete charge of the Illinois Department of Transportation's Region in which the work under contract is located.

101.34 Resident Engineer/Resident Technician. The authorized representative of the Engineer in immediate charge of the engineering details of a construction project.

101.35 Right-of-Way. A general term denoting land, property, or interest therein, usually in a strip, acquired for or devoted to transportation purposes.

101.36 Roadbed. The graded portion of a highway within side slopes, prepared as a foundation for the pavement structure and shoulders.

101.37 Roadside. A general term denoting the area adjoining the outer edge of the roadway. Extensive areas between the roadways of a divided highway may also be considered roadside.

101.38 Roadside Development. Those items necessary to the complete highway which provide for the preservation of landscape materials and features; the rehabilitation and protection against erosion of all areas disturbed by construction through seeding, sodding, mulching, and the placing of other ground covers; and such suitable planting and other improvements as may increase the effectiveness and enhance the appearance of the highway.

101.39 Roadway. The portion of the right-of-way within limits of construction.

101.40 Shoulder. The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, emergency use, and lateral support of base and surface courses.

101.41 Sidewalk. That portion of the roadway primarily constructed for the use of pedestrians.

101.42 Special Provisions. Additions and revisions to the Standard and Supplemental Specifications covering conditions peculiar to an individual contract.

101.43 Specifications. The body of directions, provisions, and requirements contained herein, or in any supplement adopted by the Department, together with written agreements and all documents of any description made or to be made pertaining to the method or manner of performing and paying for the work, the quantities, and the quality of materials to be furnished under the contract.

101.44 State.

- (a) The State of Illinois, when the State is the awarding authority.
- (b) The County, when a County is the awarding authority.
- (c) The Municipality, when a city, village, or town is the awarding authority.

101.45 Structure. Unless otherwise defined in the Specifications, structures shall comprise all objects constructed of materials other than earth, required by the contract to be built or to be removed, but not including surfacings, base courses, subbases, gutters, curbs, sidewalks, and driveway pavement.

101.46 Subcontractor. An individual, firm, partnership, or corporation who, with the written consent of the Engineer, assumes obligation for performing specified work.

101.47 Subgrade. The top surface of a roadbed upon which the pavement structure and shoulders are constructed.

101.48 Substructure. All of that part of the structure below the bearings of simple and continuous spans, skewbacks of arches, and tops of footings of rigid frames, together with the backwalls, wing walls, or wing protection railings.

101.49 Superstructure. The entire structure, except the substructure.

101.50 Supplemental Specifications. Additions and revisions to the Standard Specifications contained herein that are adopted subsequent to issuance of this book.

101.51 Surety. The corporation, partnership, or individual, other than the Contractor, executing the Contract Bond.

101.52 Traffic Control Plan. Those portions of the contract plans, Special Provisions, Specifications, and Supplemental Specifications having to do with temporary traffic control.

101.53 Traveled Way. The portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

101.54 Utility. The privately, publicly, municipally, or cooperatively owned line, facility, or system for producing, transmitting, or distributing communications,

cable television, power, electricity, light, heat, gas, oil, crude products, water, steam, or waste water. The term "utility" shall also mean the utility company, inclusive of any wholly owned or controlled subsidiary.

Utility, as defined here, includes street lighting systems, traffic signal systems, railroad warning device systems, or fire/police pre-emptors, or their collateral cables and conduits.

101.55 Work. Work shall mean the furnishing of all labor, materials, tools, equipment, and other incidentals necessary or convenient to the successful completion of the project and the carrying out of all duties and obligations imposed by the contract. Work may also be used in context to describe, in whole or in part, the completed facilities to be constructed, altered or removed, as detailed in the Contract. The Engineer will have exclusive authority to determine the intent and meaning of the usage of this term wherever it appears in the Contract.

SECTION 102. ADVERTISEMENT, BIDDING, AWARD, AND CONTRACT EXECUTION

102.01 Procedures to be in Accordance with Rules. The procedures for the advertisement, bidding, award, and contract execution shall be in accordance with the rules of the Department published at 44 Illinois Administrative Code 650 and 660. The invitation for bids contains additional requirements published in accordance with the rules. Bidders and the Contractor shall comply with the rules and all procedures published in the invitation for bids.

SECTION 103. RESERVED

SECTION 104. SCOPE OF WORK

104.01 Intent of the Contract. The intent of the contract is to prescribe a complete outline of work which the Contractor undertakes to do in full compliance with the plans and specifications. The Contractor shall perform all earthwork, construct all base and surface courses, structures, and such additional, extra, and incidental construction as may be necessary to complete the work to the finished lines, grades, and cross sections in an acceptable manner. The Contractor shall furnish all required materials, equipment, tools, labor, and incidentals, unless otherwise provided in the contract, and shall include the cost of these items in the unit prices bid for the work. The quantities appearing in the bid schedule of prices are estimates prepared for the establishment of pay item prices and the comparison of bids. Payment to the Contractor will be made for the actual measured quantities performed and accepted or material furnished and accepted according to the contract, and the scheduled quantities may be increased, decreased, or omitted as herein provided.

Under no circumstances shall the Contractor exceed any established pay item quantity without notification to the Engineer and receipt of written authorization as provided herein.

104.02 Alterations, Cancellations, Extensions, Deductions, and Extra Work. The Department reserves the right to make, in writing, at any time during work, changes in quantities, alterations in work, and the performance of extra work to satisfactorily complete the project. Such changes in quantities, alterations, and extra work shall not invalidate the contract nor release the surety, and the Contractor agrees to perform the work as altered.

If the alterations or changes in quantities significantly change the character of the work under the contract, whether or not changed by any such different quantities or alterations, an adjustment, excluding loss of anticipated profits, will be made to the contract. The basis for the adjustment shall be agreed upon prior to the performance of the work. If a basis cannot be agreed upon, then an adjustment will be made either for or against the Contractor in such amount as the Engineer may determine to be fair and equitable.

If alterations or changes in quantities do not significantly change the character of the work to be performed under contract, the altered work will be paid for as provided elsewhere in the contract.

The term "significant change" shall be construed to apply only when the character of the work as altered differs materially in kind or nature from that involved or included in the original proposed construction or when a major item, defined as an item whose total original contract costs exceeds ten percent of the total original contract amount, is increased in excess of 125 percent or decreased below 75 percent of the original contract quantity.

All alterations, cancellations, extensions, and deductions shall be authorized in writing by the Engineer before work is started. Such authorizations shall set up the items of work involved and the method of payment for each item.

The Contractor shall accept payment for alterations which result in an increase or decrease in the quantities of work to be performed according to the following.

- (a) All increases in work of the type which appear in the contract as pay items accompanied by unit prices will, except as provided under paragraph (d) herein, be paid for at the contract unit prices. Decreases in quantities included in the contract will be deducted from the contract at the unit bid prices. No allowance will be made for delays or anticipated profits.
- (b) Major items of work for which the quantities are increased by not more than 125 percent or reduced to not less than 75 percent of the original contract quantities will be paid for as specified in paragraph (a) above. Any adjustments for increased quantities for major items of work increased more than 125 percent shall only apply to that portion in excess of 125 percent of original contract quantities. Any adjustments made for major items of work which are decreased to less than 75 percent of the original contract quantities shall apply to the actual amount of work performed.
- (c) Extra work which is not included in the contract as pay items at unit prices and is not included in other items of the contract will be paid for according to Article 109.04.

- (d) Extra work for which there is a pay item at unit price in the contract which for any one or more of the following reasons materially increases or decreases the cost of the pay item as bid and which is not included in the prices bid for other items in the contract will be paid for according to Article 109.04. This includes:
 - (1) Work involving a substantial change of location.
 - (2) Work which differs in design.
 - (3) Work requiring a change in the type of construction.
- (e) In cases where the Department cancels or alters any portion of the contract items, items which are partially completed will be paid for as specified in Article 109.06.

Claims for extra work which have not been authorized in writing by the Engineer will be rejected.

104.03 Differing Site Conditions. During the progress of the work, if subsurface or latent physical conditions are encountered at the site differing materially from those indicated in the contract or if unknown physical conditions of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the work provided for in the contract, are encountered at the site, the party discovering such conditions shall promptly notify the other party in writing of the specific differing conditions before they are disturbed and before the affected work is performed.

Upon written notification, the Engineer will investigate the conditions, and if he/she determines the conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any work under the contract, an adjustment, excluding loss of anticipated profits, will be made and the contract modified in writing accordingly. The Engineer will notify the Contractor of his/her determination whether or not an adjustment of the contract is warranted.

No contract adjustment which results in a benefit to the Contractor will be allowed unless the Contractor has provided the required written notice. No contract adjustment will be allowed for any effects caused on unchanged work.

Any adjustment in compensation because of a change or changes resulting from one or more of the conditions described in the foregoing paragraph will be made according to the provisions of Article 104.02. Any adjustment in contract time because of such change or changes will be made according to the provisions of Article 108.08.

104.04 Maintenance of Detours. When the road upon which construction is in progress is closed to public use by the Engineer, the Contractor will, unless otherwise specified, be relieved of all responsibility in connection with the maintenance or marking of suitable detours.

104.05 Rights In and Use of Materials Found on the Work. The Contractor, with the approval of the Engineer, may use on the work such stone, gravel, sand, or

other material determined suitable by the Engineer as may be found in the excavation, and will be paid both for the excavation of such materials at the corresponding contract unit price and for the pay item for which the excavated material is used. The Contractor shall replace, at no additional cost to the Department, with other acceptable material, all of that portion of the excavation material so removed and used which was needed for use in the embankments, backfills, approaches, or otherwise. No charge for the materials so used will be made against the Contractor. The Contractor shall not excavate or remove any material from within the highway location which is not within the grading limits, as indicated by the slope and grade lines, without written authorization from the Engineer.

Unless otherwise provided, the material from any existing old structure may be used temporarily by the Contractor in the erection of the new structure. Such material shall not be cut or otherwise damaged, except with the approval of the Engineer.

104.06 Final Clean Up. Before final acceptance, all borrow pits and ground occupied by the Contractor in connection with the work shall be cleaned of all rubbish, excess materials, temporary structures, and equipment, and all parts of the work shall be left in a neat and presentable condition.

The Contractor shall clean off all cement streaks or drippings, paint smears or drippings, rust stains, oil, grease, bituminous materials, dirt, and other foreign materials deposited or accumulated on or in any structure or curb and gutter due to the Contractor's operations.

104.07 Value Engineering Proposals. The Contractor may submit to the Department in writing, proposals for modifying the contract documents to provide innovative, alternative lower cost construction without impairing the essential functions and characteristics of the facility including, but not limited to, service life, reliability, economy of operation, ease of maintenance, necessary standardized features, desired appearance, or design standards.

(a) Proposal Submittals. Value Engineering Proposals shall be submitted in two phases as follows.

- (1) Concept Phase. Prior to the submittal of any Value Engineering Proposal, the Contractor shall submit a brief summary outlining the concept of the proposal to the Central Bureau of Construction and the District Office. Within five working days after receipt of the proposal concept, the Department will notify the Contractor as to whether or not the proposal concept qualifies for consideration as Value Engineering. If it appears, based on the concept, the actual proposal will require a review period exceeding the normal review period, as outlined below, the Contractor will be so advised. Approval of the concept does not constitute or imply approval of the subsequent submittal of the complete Value Engineering Proposal.
- (2) After the concept has been approved, the Contractor, if electing to proceed with submittal of the complete Value Engineering Proposal, shall submit the proposal simultaneously to the District and the Central Bureau of Construction for review. The District will forward their recommendations to the Central Bureau of Construction within ten

working days after receipt of the proposal, provided the proposal is complete and contains all the required information for review. The Central Bureau of Construction will notify the Contractor as to the acceptability of the proposal within five working days of receipt of the District's recommendation, unless additional review time has been established as noted in the concept review process.

- (b) Contents of Proposal. Value Engineering Proposals shall contain the following information.
 - (1) A Statement that the proposal is submitted as a Value Engineering Proposal.
 - (2) A complete description detailing the proposed modification to the contract documents.
 - (3) A complete cost analysis detailing the unit costs and quantities to be deleted and/or added by the proposal.
 - (4) A complete analysis of the impact the proposed modification will have on the prosecution and progress of the contract.
- (c) Consideration of Proposal. The following conditions will govern the consideration of Value Engineering Proposals.
 - (1) All proposals apply only to the contract under which it is submitted. The Contractor will be guaranteed propriety of authorship as well as ownership of the proposal until such time it is approved by the Department. The Department will have the right to use, duplicate, and disclose, in whole or in part, any data necessary for the utilization of the proposal. The Department retains the right to utilize any accepted proposal or part thereof on any other or subsequent contracts without obligation to the Contractor. This provision is not intended to deny rights provided by law with respect to patented materials or processes.
 - (2) If the Department has under consideration certain revisions or modifications to the contract at the time of execution of the contract, the Contractor will be so notified at the preconstruction conference. Revisions or modifications to the contract generated by the Department shall not be incorporated into any Value Engineering Proposal submitted by the Contractor.
 - (3) The proposal shall not consist of any experimental products or materials to be incorporated. However, proposals containing the use of alternate methods and equipment, as allowed under Article 108.06, may be presented for consideration.
 - (4) The reduction of quantities or deletion of items of work which result from adjustment of the contract to meet field conditions as allowed under Article 104.02 shall not be incorporated into any Value Engineering Proposal. Proposals based solely on the waiving of specifications or contract requirements will not be considered.

- (5) The proposal must be submitted and approved prior to undertaking any work on the proposed modification.
 - (6) The Contractor shall have no claim against the Department for any costs or delays resulting from the review process and/or disapproval of any Value Engineering Proposal, including but not limited to, development costs, anticipated profits, increased material cost, and increased labor costs.
 - (7) The Department will be the sole judge as to the acceptability of a proposal and the estimated net savings resulting from implementation of the proposal. In determining the estimated net savings, the right is reserved to disregard the contract bid prices if, in the judgement of the Engineer, such prices do not represent a fair measure of the value of work to be performed or to be deleted.
 - (8) The Department reserves the right where it deems such action appropriate, to require the Contractor to share in the costs of reviewing and investigating any Value Engineering Proposal. When this requirement is imposed, the Contractor shall indicate his/her acceptance thereof in writing, and such acceptance shall constitute full authority for the Department to deduct amounts payable to the Contractor from any monies due or that may become due to the Contractor under the contract.
 - (9) The Contractor shall be responsible for any modification of the contract plans required as part of the Value Engineering Proposal. When contract plan modifications are included as part of the proposal, the Contractor shall furnish a copy of the modifications to the Department and shall be solely responsible for any errors or omissions resulting from the modification.
- (d) Acceptance of the Proposal. If the Value Engineering Proposal is accepted, the changes will be incorporated into the contract through changes in the quantities of unit bid items, new agreed price items, or by force account, as appropriate. The cost of the revised work will be paid directly as completed. In addition to such payment, the Department will pay the Contractor a Value Engineering Incentive according to the following criteria.
- A = Adjusted cost
 - B = Original cost
 - C = Department's cost incurred as a result of investigation and application of the proposal
- (1) For contracts less than \$1,000,000 in awarded value, the Contractor will be paid as follows.
 - a. When the total cumulative value of all Value Engineering Proposals submitted for an individual contract is equal to or less than 1.5 percent of the awarded contract value, payment will be 0.5 (B-A-C).

- b. When the total cumulative value of all Value Engineering Proposals submitted for an individual contract is greater than 1.5 percent of the awardable contract value, payment will be 0.65 (B-A-C) for that portion of the cumulative value that exceeds 1.5 percent of the awarded contract value, plus 0.5 (B-A-C) for that portion to and including 1.5 percent.
- (2) For contracts that are at least \$1,000,000 but do not exceed \$5,000,000 in awarded value, the Contractor will be paid as follows.
- a. When the total cumulative value of all Value Engineering Proposals submitted for an individual contract is equal to or less than 2.0 percent of the awarded contract value, payment will be 0.5 (B-A-C).
 - b. When the total cumulative value of all Value Engineering Proposals submitted for an individual contract is greater than 2.0 percent of the awarded contract value, payment will be 0.65 (B-A-C) for that portion of the cumulative value that exceeds 2.0 percent of the awarded contract value, plus 0.5 (B-A-C) for that portion up to and including 2.0 percent.
- (3) For contracts that exceed \$5,000,000 in awarded value, the Contractor will be paid as follows.
- a. When the total cumulative value of all Value Engineering Proposals submitted for an individual contract is equal to or less than 1.0 percent of the awarded contract value, payment will be 0.5 (B-A-C).
 - b. When the total cumulative value of all Value Engineering Proposals submitted for an individual contract is greater than 1.0 percent of the awarded contract value, payment will be 0.65 (B-A-C) for that portion of the cumulative value that exceeds 1.0 percent of the awarded contract value, plus 0.5 (B-A-C) for that portion up to and including 1.0 percent.

SECTION 105. CONTROL OF WORK

105.01 Authority of Engineer. All work of the contract shall be completed to the satisfaction of the Engineer. The decision of the Engineer shall be final on all questions which may arise regarding, including but not limited to, the quality and acceptability of materials and work; the manner of performance; acceptable rates of progress on the work; the interpretation of the contract plans and specifications; the fulfillment of the contract; the measurement of quantities and payment under the contract; and the determination of the existence of changed or differing site conditions.

The Engineer will notify the Contractor in writing if the work is to be suspended wholly or in part due to the failure of the Contractor to carry out provisions of the

contract or failure to carry out orders of the Engineer. The work may also be suspended at the Contractor's risk for such periods as the Engineer may deem necessary due to unsuitable weather; for conditions considered unsuitable for the prosecution of the work or for any other condition or reason deemed to be in the public interest.

The contract does not require the Engineer to provide the Contractor with direction or advice on how to do the work. If the Engineer approves or recommends any method or manner for doing the work, the approval or recommendation shall not guarantee following the method or manner will result in compliance with the contract, relieve the Contractor of the risks and obligations of the contract, or create liability for the Department.

In case of failure on the part of the Contractor to execute work ordered by the Engineer, the Engineer may, at the expiration of a period of 48 hours after giving notice in writing to the Contractor, proceed to execute such work as may be deemed necessary, and the cost thereof will be deducted from compensation due or which may become due the Contractor under the contract.

105.02 Authority of Railroad Engineer. Whenever the safety of railroad traffic is concerned, the Railroad Engineer will have jurisdiction over safety measures to be taken and his/her decision as to methods, procedures, and measures used shall be final, and any and all Contractors performing work near or about the railroad shall be governed by such decision. Instructions to the Contractor by the Railroad Engineer will be given through the Engineer. Work ordered as specified herein will be classified and paid for according to Article 104.02. Work performed for the Contractor's convenience will not be paid for separately but shall be considered as included in the contract.

105.03 Conformity with Contract. All work performed and all materials furnished shall be in conformity with the contract and the lines, grades, cross sections, dimensions, and material requirements, including tolerances, shown on the plans or indicated in the contract documents. All work or material which does not conform to the requirements of the contract will be considered unacceptable.

Unacceptable work; whether the result of poor workmanship, use of defective materials, damage through carelessness, or other cause; and unacceptable material shall be removed and replaced or otherwise corrected in an acceptable manner at no additional cost to the Department.

The Department reserves the right to accept work produced by the Contractor if the Engineer finds the noncompliant materials, the finished product in which the noncompliant materials are used, or the nonconforming work are in close conformity with the contract. In this event, the Engineer will document the basis of acceptance by contract modification which may provide for an appropriate adjustment in the contract price for such work or materials as the Engineer deems necessary to conform to the determination. The determination of the Department will be based on the best engineering judgement of the Engineer and shall be final and binding.

Work done contrary to instructions given by the Engineer, work done beyond the lines shown on the plans, or as given by the Engineer, or any extra work done without written approval given by the Engineer will be considered as unacceptable and will

not be paid for under the contract. Work so done may be ordered removed or replaced at no additional cost to the Department.

For unacceptable work that impacts the environment or public safety, a deduction will be applied to monies due or that might become due the Contractor. These deficiency deductions will be applied as follows.

- (a) National Pollutant Discharge Elimination System (NPDES) / Erosion and Sediment Control Deficiency Deduction. When the Engineer is notified or determines an erosion and/or sediment control deficiency(s) exists, or the Contractor's activities represents a violation of the Department's NPDES permits, the Engineer will notify and direct the Contractor to correct the deficiency within a specified time. The specified time, which begins upon notification to the Contractor, will be from 1/2 hour to 1 week based on the urgency of the situation and the nature of the work effort required. The Engineer will be the sole judge.

A deficiency may be any lack of repair, maintenance, or implementation of erosion and/or sediment control devices included in the contract, or any failure to comply with the conditions of the Department's NPDES permits. A deficiency may also be applied to situations where corrective action is not an option such as the failure to participate in a jobsite inspection of the project, failure to install required measures prior to initiating earth moving operations, disregard of concrete washout requirements, or other disregard of the NPDES permit.

If the Contractor fails to correct a deficiency within the specified time, a daily monetary deduction will be imposed for each calendar day or portion of a calendar day until the deficiency is corrected to the satisfaction of the Engineer. The calendar day(s) will begin with notification to the Contractor and end with the Engineer's acceptance of the correction. The base value of the daily monetary deduction is \$1000.00. The value of the deficiency deduction assessed will be determined by multiplying the base value by a Gravity Adjustment Factor provided in Table A; except for failure to participate in a required jobsite inspection of the project prior to initiating earthmoving operations which will be based on the total acreage of planned disturbance at the following multipliers: <5 Acres: 1; 5-10 Acres: 2; >10-25 Acres: 3; >25 Acres: 5. For those deficiencies where corrective action was not an option, the monetary deduction will be immediate and will be valued at one calendar day multiplied by a Gravity Adjustment Factor.

Table A Deficiency Deduction Gravity Adjustment Factors				
Types of Violations	Soil Disturbed and Not Permanently Stabilized At Time of Violation			
	< 5 Acres	5 - 10 Acres	>10 - 25 Acres	> 25 Acres
Failure to Install or Properly Maintain BMP	0.1 - 0.5	0.2 - 1.0	0.5 - 2.5	1.0 - 5
Careless Destruction of BMP	0.2 - 1	0.5 - 2.5	1.0 - 5.	1.0 - 5
Intrusion into Protected Resource	1.0 - 5	1.0 - 5	2.0 - 10	2.0 - 10
Failure to properly manage Chemicals, Concrete Washouts or Residuals, Litter or other Wastes	0.2 - 1	0.2 - 1	0.5 - 2.5	1.0 - 5
Improper Vehicle and Equipment Maintenance, Fueling or Cleaning	0.1 - 0.5	0.2 - 1	0.2 - 1	0.5 - 2.5
Failure to Provide or Update Written or Graphic Plans Required by SWPPP	0.2 - 1	0.5 - 2.5	1.0 - 5	1.0 - 5
Failure to comply with Other Provisions of the NPDES Permit	0.1 - 0.5	0.2 - 1	0.2 - 1	0.5 - 2.5

- (b) **Traffic Control Deficiency Deduction.** When the Engineer is notified, or determines a traffic control deficiency exists, he/she will notify and direct the Contractor to correct the deficiency within a specified time. The specified time, which begins upon notification to the Contractor, will be from 1/2 hour to 12 hours based upon the urgency of the situation and the nature of the deficiency. The Engineer shall be the sole judge.

A deficiency may be any lack of repair, maintenance, or non-compliance with the traffic control plan. A deficiency may also be applied to situations where corrective action is not an option such as the use of non-certified flaggers for short term operations; working with lane closures beyond the time allowed in the contract; or failure to perform required contract obligations such as traffic control surveillance.

If the Contractor fails to correct a deficiency within the specified time, a daily monetary deduction will be imposed for each calendar day or fraction thereof the deficiency exists. The calendar day(s) will begin with notification to the Contractor and end with the Engineer's acceptance of the correction. The daily monetary deduction will be either \$1,000 or 0.05 percent of the awarded contract value, whichever is greater. For those deficiencies where corrective action was not an option, this monetary deduction will be immediate.

The statement elsewhere in the contract of remedies for the use of unacceptable materials or for unacceptable work shall not be exclusive of the remedies provided in this Article unless expressly provided therein.

Upon failure of the Contractor to comply with any order of the Engineer made under the provisions of this Article, the Engineer will have authority to cause the unacceptable work, or deficiency(s), to be corrected, removed or replaced, and to deduct the cost from any monies due or to become due the Contractor. This corrective action will in no way relieve the Contractor of their contractual requirements or responsibilities.

105.04 Plans and Working Drawings. Plans showing details as are necessary to give a comprehensive idea of the construction contemplated will be furnished by the Department. The Department reserves the right to further detail and illustrate the work. The Engineer may furnish the Contractor additional plans and explanations consistent with the original plans. The Contractor shall perform the work according to these additional plans and explanations.

The Contractor shall submit to the Engineer for approval such additional shop, working, or layout drawings pertaining to the construction of the work, as may be required, and prior to the approval of such plans or drawings, any work done or materials ordered shall be at the Contractor's risk. The drawings shall be provided sufficiently in advance of actual need in order to allow for review by the Department and other agencies. The Engineer will require up to 30 calendar days for review, after receipt of the submittal, by the Department. The review may involve rejection, revision, or resubmittal when drawings do not meet contract requirements or do not contain sufficient detail, in which case, an additional 30 calendar days will be required for each subsequent review. The written approval of the Engineer is required before proceeding with the work represented by the drawings. Approval by the Engineer shall not confer upon the Department any responsibility for the accuracy of the drawings. The Contractor shall bear all risk and costs for work delay caused by nonapproval of the drawings.

When the contract includes work adjacent to a railroad and falsework, cofferdams, or sheeting is required, the Contractor shall submit to the Engineer for approval and the Railroad Engineer's approval, plans for the falsework, cofferdams, or sheeting. The plans shall be submitted sufficiently in advance of the time the Contractor intends to start work to permit checking. No such work shall be started prior to receipt by the Contractor of approval of the plans for the falsework, cofferdams, or sheeting. The Contractor shall give the Railroad Engineer not less than ten days notice, in writing, prior to beginning of such construction. The cost of furnishing such drawings shall be included in the contract and no additional compensation will be allowed the Contractor for any delays resulting therefrom.

105.05 Coordination of the Contract Documents. The documents included in the contract are intended to be complementary and to describe a complete work. If the Department determines a conflict exists between the contract documents, the following hierarchy will be applied and the Contractor shall then complete the work according to the interpretation made by the Department.

Hierarchy of the Contract Documents		
Special Provisions	Hold over:	Plans, Recurring Special Provisions, Supplemental Specifications, and Standard Specifications
Plans ^{1/, 2/, 3/}	Hold over:	Recurring Special Provisions, Supplemental Specifications, and Standard Specifications
Recurring Special Provisions	Hold over:	Supplemental Specifications, and Standard Specifications
Supplemental Specifications	Hold over:	Standard Specifications

1/ Detail plans hold over Highway Standards.

2/ Calculated dimensions hold over scaled dimensions.

3/ The Highway Standards indicated by the revision number listed in the Index of Highway Standards on the plans shall hold over Highway Standards listed anywhere else.

105.06 Cooperation by Contractor. The Contractor will be supplied with a minimum of two sets of approved plans and contract assemblies including Special Provisions, one set of which the Contractor shall keep available on the work at all times.

The Contractor shall give the work constant attention necessary to facilitate the progress thereof, and shall cooperate with the Engineer, appointed inspectors, and other contractors in every way possible.

The Contractor shall have on the work at all times, as the Contractor's agent, a competent English-speaking superintendent, capable of reading and thoroughly understanding the plans and Specifications and thoroughly experienced in the type of work being performed, who shall receive instructions from the Engineer or authorized representatives. The superintendent shall have full authority to execute orders or directions of the Engineer without delay, and to promptly supply such materials, equipment, tools, labor, and incidentals as may be required. Such superintendent shall be furnished irrespective of the amount of work sublet.

105.07 Cooperation with Utilities. The adjustment of utilities consists of the relocation, removal, replacement, rearrangements, reconstruction, improvement, disconnection, connection, shifting, new installation, or altering of an existing utility facility in any manner.

- (a) **Known Utilities.** All known existing utilities are indicated on the plans. Utilities which are to be adjusted shall be adjusted by the utility owner or the owner's representative or by the Contractor as a contract item. Generally, arrangements for adjusting known utilities will be made by the Department prior to project construction; however, utilities will not necessarily be adjusted in advance of project construction and, in some cases, utilities will

not be removed from the proposed construction limits. When utility adjustments must be performed in conjunction with construction, the utility adjustment work will be shown on the plans and/or covered by Special Provisions.

When the Contractor discovers a utility has not been adjusted by the owner or the owner's representative as indicated in the contract documents, or the utility is not shown on the plans or described in the Special Provisions as to be adjusted in conjunction with construction, the Contractor shall not interfere with said utility, and shall take proper precautions to prevent damage or interruption of the utility and shall promptly notify the Engineer of the nature and location of said utility.

(1) Limits of Proposed Construction for Utilities Paralleling the Roadway. For the purpose of this Article, limits of proposed construction for utilities extending in the same longitudinal direction as the roadway, shall be defined as follows.

- a. The horizontal limits shall be a vertical plane, outside of, parallel to, and 2 ft (600 mm) distant at right angles from the plan or revised slope limits.

In cases where the limits of excavation for structures are not shown on the plans, the horizontal limits shall be a vertical plane 4 ft (1.2 m) outside the edges of structure footings or the structure where no footings are required.

- b. The upper vertical limits shall be the regulations governing the roadbed clearance for the specific utility involved.
- c. The lower vertical limits shall be either the top of the utility at the depth below the proposed grade as prescribed by the governing agency or the limits of excavation, whichever is less.

(2) Limits of Proposed Construction for Utilities Crossing the Roadway. For the purpose of this Article, limits of proposed construction for utilities crossing the roadway in a generally transverse direction shall be defined as follows.

- a. Utilities crossing excavations for structures that are normally made by trenching such as sewers, underdrains, etc. and all minor structures such as manholes, inlets, foundations for signs, foundations for traffic signals, etc., the limits shall be the space to be occupied by the proposed permanent construction, unless otherwise required by the regulations governing the specific utility involved.
- b. For utilities crossing the proposed site of major structures such as bridges, sign trusses, etc., the limits shall be as defined above for utilities extending in the same general direction as the roadway.

The Contractor shall request all utility owners to field locate their facilities according to Article 107.31. The Engineer may make the request for location from the utility after receipt of notice from the Contractor. On request, the Engineer will make an inspection to verify that the utility company has field located its facilities, but will not assume responsibility for the accuracy of such work. The Contractor shall be responsible for maintaining the excavations or markers provided by the utility owners. This field location procedure may be waived if the utility owner has stated in writing to the Department it is satisfied the construction plans are sufficiently accurate. If the utility owner does not submit such statement to the Department, and they do not field locate their facilities in both horizontal and vertical alignment, the Engineer will authorize the Contractor in writing to proceed to locate the facilities in the most economical and reasonable manner, subject to the approval of the Engineer, and be paid according to Article 109.04.

The Contractor shall coordinate with any planned utility adjustment or new installation and the Contractor shall take all precautions to prevent disturbance or damage to utility facilities. Any failure on the part of the utility owner, or their representative, to proceed with any planned utility adjustment or new installation shall be reported promptly by the Contractor to the Engineer orally and in writing.

The Contractor shall take all necessary precautions for the protection of the utility facilities. The Contractor shall be responsible for any damage or destruction of utility facilities resulting from neglect, misconduct, or omission in the Contractor's manner or method of execution or nonexecution of the work, or caused by defective work or the use of unsatisfactory materials. Whenever any damage or destruction of a utility facility occurs as a result of work performed by the Contractor, the utility company will be immediately notified. The utility company will make arrangements to restore such facility to a condition equal to that existing before any such damage or destruction was done.

The Contractor may make arrangements for adjustment of utilities outside of the limits of proposed construction provided the Contractor furnishes the Department with a signed agreement with the utility owner covering the adjustments to be made. The cost of any adjustments made outside the limits of proposed construction shall be the responsibility of the Contractor, unless otherwise provided.

It is understood and agreed that the Contractor has considered in the bid all of the permanent and temporary known utilities in their present and/or adjusted positions.

No additional compensation will be allowed for any delays, inconveniences, or damages sustained by the Contractor due to the presence of or any claimed interference from the said known utility facilities or any adjustment of them.

- (b) Unknown Utilities. Except as provided hereinafter, the discovery of an unknown utility will be evaluated according to Article 104.03.

- (1) Definition. An unknown utility is defined as an active or inactive underground utility, which is neither (a) shown in any way in any location on the contract documents; nor (b) identified in writing by the Department to the Contractor prior to the letting. Service connections shall not be considered to be unknown utilities.
- (2) Compensation. Compensation will not be allowed for delays, inconveniences, or damages sustained by the Contractor from unknown utilities not meeting the above definition or if the discovery of an unknown utility does not cause a shutdown of the work applicable to the utility but only a change in the rate of progress. The provisions of Article 104.03 notwithstanding, compensation for unknown utility delays determined to be a changed condition will be paid according to the provisions of this Article governing minor and major delays.
- (3) Minor and Major Delays. Minor and Major Delays are defined as follows.
 - a. Minor Delay. When the Contractor's operation is stopped by the unknown utility for more than two hours, but not to exceed three weeks.
 - b. Major Delay. When the Contractor's operation is stopped by the unknown utility for more than three weeks.
- (4) Payment. Payment for Minor and Major Delays will be made as follows.
 - a. Minor Delay. Labor idled which cannot be used on other work will be paid for according to Article 109.04(b)(1) and (2) for the time between start of the delay and the minimum remaining hours in the work shift required by the prevailing practice in the area.

Equipment idled which cannot be used on other work, and which is authorized to standby on the project site by the Engineer, will be paid for according to Article 109.04(b)(4).

Additional traffic control required as a result of the operation(s) delayed will be paid for according to Article 109.04.
 - b. Major Delay. Labor will be the same as for a Minor Delay.

Equipment will be the same as for a Minor Delay, except Contractor-owned equipment will be limited to three weeks plus the cost of move-out to either the Contractor's yard or another job, whichever is less. Rental equipment may be paid for longer than three weeks provided the Contractor presents adequate support to the Department (including lease agreement) to show retaining equipment on the job is the most economical course to follow and in the public interest.

Additional traffic control required as a result of the operation(s) delayed will be paid for according to Article 109.04 for the total length of the delay.

If the delay is clearly shown to have caused work, which would have otherwise been completed, to be done after material or labor costs have increased, such increases may be paid. Payment for materials will be limited to increased cost substantiated by documentation furnished by the Contractor. Payment for increased labor rates will include those items in Article 109.04(b)(1) and (2), except the 35 percent and ten percent additives will not be permitted. A delay occurring between November 30 and May 1, when work has not started, will not be considered as eligible for payment of measured labor and material costs.

Project overhead (not including interest) will be allowed when all progress on the contract has been delayed, and will be calculated as 15 percent of the delay claim.

- (5) Other Obligations of Contractor. Upon payment of a claim under this provision, the Contractor shall assign subrogation rights to the Department for the Department's efforts of recovery from any other party for monies paid by the Department as a result of any claim under this Provision. The Contractor shall fully cooperate with the Department in its efforts to recover from another party any money paid to the Contractor for delay damages under this Provision.

105.08 Cooperation Between Contractors. The Department reserves the right at any time to contract for and perform other or additional work on or near the work covered by the contract. Each Contractor shall conduct his/her work so as not to interfere with or hinder the progress or completion of the work being performed by other Contractors. In case of dispute, the Engineer shall be the referee and the Engineer's decision shall be final and binding on all.

Each Contractor involved shall assume all liability, financial or otherwise, in connection with his/her contract, and shall protect and save harmless the Department from any and all damages or claims that may arise because of inconvenience, delay, or loss experienced by the Contractor because of the presence and operation of other Contractors working within the limits of the same improvement. Each Contractor shall assume all responsibility for all work not completed or accepted because of the presence and operations of the other Contractors.

The Contractor shall arrange the work and shall place and dispose of the materials being used so as not to interfere with the operations of the other Contractors within the limits of the same project. The Contractor shall join his/her work with that of the others in an acceptable manner and shall perform it in proper sequence to that of the others.

105.09 Survey Control Points. Survey control points will be set by the Engineer, unless specified otherwise in the contract, to establish the horizontal and vertical control required for construction of the various contract items of work. The Department will be responsible for the accuracy of the control points and other lines

and elevations set by the Engineer. The Contractor shall assume full responsibility for all dimensions and measurements taken or derived by the Contractor from control points set by the Engineer.

The Contractor shall preserve and protect all control points set by the Engineer. If the Contractor removes, disturbs, or otherwise displaces any control point, without the prior approval of the Engineer, the Engineer may deduct the direct engineering cost incurred by the Department in re-establishing the control point from compensation due the Contractor.

The Contractor shall furnish, as directed by the Engineer, the type, size, quality, and quantity of material required to establish control points for the work. The cost incurred by the Contractor in complying with this requirement shall be considered as included in the contract unit prices bid for the various items of work involved and no additional compensation will be allowed.

105.10 Authority and Duties of Resident Engineer. The Resident Engineer is responsible for the administration and satisfactory completion of an assigned construction project. The Resident Engineer has the authority to reject defective work or material and to suspend any work being improperly performed.

105.11 Duties of the Inspector. Inspectors employed by the Department will be authorized to inspect all work done and materials furnished. Such inspection may extend to all or any part of the work and to the preparation, fabrication, or manufacture of the materials to be used. The inspector will not be authorized to alter or waive the provisions of the contract. The inspector will not be authorized to issue instructions contrary to the plans and Specifications, or to act as foreman for the Contractor.

105.12 Inspection of Work. All materials and each part or detail of the work shall be subject at all times to inspection by the Engineer. Such inspection may include mill, plant, or shop inspection, and any material furnished under the Specifications is subject to such inspection. The Engineer shall be allowed access to all parts of the work and shall be furnished with such information and assistance by the Contractor as is required to make a complete and detailed inspection.

If the Engineer requests, the Contractor shall remove or uncover such portions of the finished work as may be directed. After examination, the Contractor shall restore said portions of the work to the standard required by the Specifications. Should the work thus exposed or examined prove acceptable, the uncovering or removing, and the replacing of the covering or making good of the parts removed will be paid for as extra work; but should the work so exposed or examined prove unacceptable, the uncovering or removing, and the replacing of the covering or making good of the parts removed, will be at no additional cost to the Department.

When the contract includes railroad grade separation or grade crossing work, all materials for and each part or detail of the work shall be subject at all times to the inspection of the representatives of the Railroad insofar as Railroad interests are concerned, but such inspection shall in no sense make the Railroad a party to the contract.

Additional requirements for inspection of electrical work shall be according to Articles 801.09 and 801.10.

105.13 Final Inspection. Upon due notice from the Contractor of completion of the entire project, the Engineer will make an inspection. If all construction provided for and contemplated by the contract is found satisfactorily completed according to all of the requirements of the contract, the inspection shall constitute the final inspection and the Engineer will notify the Contractor in writing of the date of final inspection.

If the inspection discloses any work, in whole or in part as being unsatisfactory, the Engineer will give the Contractor the necessary instructions for correction of same, and the Contractor shall immediately comply with such instructions. Upon correction of the work, another inspection will be made which shall constitute the final inspection provided the work has been satisfactorily completed. In such event, the Engineer will notify the Contractor in writing of the date of final inspection.

Additional requirements for final inspection of electrical work shall be according to Articles 801.13 through 801.16.

SECTION 106. CONTROL OF MATERIALS

106.01 Source of Supply and Quality Requirements. The materials used on the work shall meet all quality requirements of the contract. The Contractor shall notify the Engineer of the proposed sources of materials prior to delivery. At the option of the Engineer, materials may be approved at the source of supply before delivery is started. If it is found after trial that sources of supply for previously approved materials do not produce uniform and satisfactory products, or if the product from any source proves unacceptable at any time, the Contractor shall furnish acceptable materials from other sources.

All materials to be permanently incorporated in the work shall be new unless otherwise specifically prescribed in the contract documents.

All iron and steel products, which are to be incorporated into the work shall be domestically manufactured or produced and fabricated. The Contractor shall obtain from the iron or steel producer and/or fabricator, in addition to the mill analysis, a certification that all iron or steel materials meet these domestic source requirements.

The application of all coatings, epoxy, galvanizing, painting, etc., to metal products shall be domestically applied.

Metal materials other than iron and steel, which are not domestically produced, may be accepted provided:

- (a) The Contractor notifies the Department in advance of his/her intention to use other than domestically manufactured or produced material.
- (b) Written evidence is provided in English of compliance with all requirements of the Specifications.

- (c) Physical tests conducted by the Department verify the acceptability of the material.

The Contractor is responsible for complying with these conditions so the material can be sampled and tested prior to the time it is required, and no material shall be incorporated in the work until approval is obtained from the Engineer.

106.02 Unacceptable Materials. All materials not conforming to the requirements of the contract at the time they are used will be considered unacceptable and all such materials will be rejected and shall be removed immediately from the site of the work unless otherwise instructed by the Engineer. If in place, they shall be removed and replaced with acceptable materials at no additional cost to the Department. No rejected material, the defects of which have been corrected, shall be used until approval has been given. Upon failure of the Contractor to comply forthwith with any order of the Engineer pursuant to the provisions of this Article, the Engineer shall have authority to remove and replace defective materials and to deduct the cost of removal and replacement from any monies due or to become due the Contractor.

106.03 Samples, Tests, and Cited Specifications. All materials shall be inspected, tested, and approved by the Engineer before incorporation in the work. The Contractor shall give sufficient advance notice of placing orders to permit tests to be completed before the materials are incorporated in the work, and the Contractor shall afford such facilities as the Engineer may require for collecting and forwarding samples and making inspections. All samples shall be furnished without charge to the Department.

Any work in which untested and unaccepted materials are used without approval or written permission of the Engineer shall be performed at the Contractor's risk and may be considered as unacceptable or unauthorized and will not be paid for. Unless otherwise designated, tests will be made by and at the expense of the Department. Samples will be taken by a qualified representative of the Department. All materials being used are subject to inspection, test or rejection at any time. When requested by the Department, the Contractor shall furnish a complete written statement of the origin, composition, and manufacture of any or all materials (manufactured, produced, or grown) to be used in the work.

Wherever in the contract an abbreviated citation, from those listed in Article 101.01, is used followed by an appropriate serial designation, it shall be construed to mean the latest test or specification as the case may be, either as standards, tentative standards, interims, revisions, or amendments, in effect on the date of invitation for bids.

106.04 Plant Inspection. The Engineer may undertake the inspection of materials at the source. In the event plant inspection is undertaken, the Engineer shall have the cooperation and assistance of the Contractor and the source with whom the Contractor has contracted for materials, and shall have full entry at all times to such parts of the plant as may concern the manufacture or production of the materials being furnished.

If required by the Engineer, the source of supply shall furnish an approved building for the use of the inspector. Such building shall be located conveniently near

the plant independent of any building used by the source, and equipped essentially to the requirements of Article 670.04.

It is understood that the Department reserves the right to retest all materials which have been tested and accepted at the source of supply after the same have been delivered, and to reject all materials which, when retested, do not meet the requirements of the contract.

When required by the Engineer, the following shall be provided by the Contractor, or source of supply.

- (a) All necessary testing equipment and labor to test samples.
- (b) An approved sampling location and the necessary personnel to assist the Department representative in obtaining samples.
- (c) Adequate safety measures provided and maintained.

106.05 Source of Materials. The source of supply, of each material used, shall be approved by the Engineer before delivery is started. If sources previously approved are found to be unacceptable at any time and fail to produce materials satisfactory to the Department, the Contractor shall furnish materials from other approved sources.

If the Contractor decides to investigate new sources of supply, the Contractor shall furnish without charge such preliminary samples as the Department may require. Tests will be made on these preliminary samples and reports rendered, but it is understood that such tests are for informational purposes only and tests shall not be construed as a guarantee of acceptance of any material which may be delivered later for incorporation in the work. Only materials actually delivered for use will be considered, and their acceptance will be based solely upon the results of the tests made on these materials.

If the Contractor installs equipment or apparatus to produce materials from new sources of supply, the Contractor does so at his/her own risk, and the Contractor shall assume full responsibility for the production of uniform and satisfactory materials. In case of failure of a source of supply to produce materials satisfactory to the Department, the Contractor shall indemnify and save harmless the Department from any and all claims for loss or damage of whatever nature which the Contractor may have suffered by reason of the installation of equipment and the operation of such sources of supply.

When materials are furnished to the Contractor by the Department for inclusion in the work, the Contractor's responsibility for all such materials shall be the same as for materials furnished by the Contractor.

106.06 Stored Materials. If it is necessary to store materials, they shall be protected in such a manner as to ensure the preservation of their quality and fitness for the work. All stored materials will be inspected at the time of use in the work, even though they may have been inspected and approved before being placed in storage. The Contractor may use the right-of-way for storage of materials, but the stockpiles shall be confined to such cleared areas as approved by the Engineer. If stockpiling is

done outside of the right-of-way, the additional space required shall be provided by the Contractor at no additional cost to the Department.

106.07 Handling Materials. All materials shall be handled in such manner as to preserve their quality and fitness for the work. Aggregates shall be transported from the storage sites to the work in tight vehicles so constructed as to prevent loss or segregation of materials after loading and measuring in order to prevent inconsistencies in the quantities of materials intended for incorporation in the work as loaded, and the quantities as actually received at the place of operations.

106.08 Certification of Metal Fabricator. All fabricators performing work on metal components of structures shall be certified under the appropriate category of the AISC Quality Certification Program as follows.

- (a) Fabricators of the main load carrying steel components of welded plate girder, box girder, truss, and arch structures shall be certified under Category MBr (Major Steel Bridges).
- (b) Fabricators of the main load carrying steel components of rolled beam structures, either simple span or continuous, and overhead sign structures shall be certified under Category SBr (Simple Steel Bridges).

Fabricators of steel or other non-ferrous metal components of structures not certified under (a) or (b) above shall be certified under the AISC program for Bridge and Highway Metal Component Manufacturers.

106.09 Electrical Work. Additional material requirements for electrical work shall be according to Articles 801.01 through 801.08.

SECTION 107. LEGAL REGULATIONS AND RESPONSIBILITY TO PUBLIC

107.01 Laws to be Observed. The Contractor shall at all times observe and comply with all Federal and State laws, local laws, ordinances, and regulations which in any manner affect the conduct of the work, and all such orders or enactments as exist at the present and which may be enacted later, of legislative bodies or tribunals having legal jurisdiction or which may have affect over the work, and no plea of misunderstanding or ignorance thereof will be considered. The Contractor shall indemnify and save harmless the State and all of its officers, agents, employees, and servants against any claim or liability arising from or based on the violation of such law, ordinance, regulation, order, or enactment, whether by the Contractor or anyone subject to the control of the Contractor.

107.02 Worker's Compensation Insurance. Prior to the approval of his/her contract by the Department, the Contractor shall furnish to the Department certificates of insurance covering Worker's Compensation, or satisfactory evidence that this liability is otherwise taken care of according to Section 4(a) of the "Worker's Compensation Act of the State of Illinois" as amended.

Such insurance, or other means of protection as herein provided, shall be kept in force until all work to be performed under the terms of the contract has been completed and accepted according to the Specifications, and it is hereby understood

and agreed the maintenance of such insurance or other protection, until acceptance of the work by the Department, is a part of the contract. Failure to maintain such insurance, cancellation by the Industrial Commission of its approval of such other means of protection as might have been elected, or any other act which results in lack of protection under the said "Worker's Compensation Act" may be considered as a breach of the contract.

107.03 Employment Preference. The Contractor shall comply with the "Veterans Preference Act" as amended. The foregoing requirements shall not be applied to discriminate or give preference to veterans of a district over veterans of any political jurisdiction, state, possession, or territory of the United States on Federal-Aid projects.

107.04 Permits and Licenses. The Contractor shall procure all permits and licenses, pay all charges and fees, and give all notices necessary and incident to the due and lawful prosecution of the work.

The Contractor before entering upon the right-of-way of a railroad for the performance of any construction work, or work preparatory thereto, shall secure permission from the Railroad Engineer for the occupancy and use of the railroad's right-of-way outside the limits of the railroad grade separation structure or grade crossing; and, in addition, the Contractor shall confer with the Railroad Engineer relative to railroad requirements for clearances, operation, and general safety regulation.

107.05 Patented Devices, Material, and Processes. If any design, device, material, or process covered by letters, patent, or copyright is used by the Contractor, whether required or not, the Contractor shall provide for such use by suitable legal agreement with the patentee or owner, guaranteeing the Department indemnity from and against all claims for infringement, and shall include the cost of such agreement in the price bid for the work. It shall be the duty of the Contractor, if so demanded by the Department, to furnish said Department with a copy of the legal agreement with the patentee or owner, and if such copy is not furnished when demanded, then the Department may, if it so elects, withhold any and all payments to said Contractor until said legal agreement is furnished. If a suitable legal agreement with the patentee or owner is not made as required herein, the Contractor and surety shall indemnify and save harmless the Department from any and all claims for infringement by reason of the use of any such patented design, device, material, or process, or any trademark or copyright in connection with the work agreed to be performed under the contract, and shall indemnify the Department for any cost, expense, and damages which it may be obliged to pay by reason of any such infringement at any time during the prosecution or after the completion of the work.

107.06 Restoration of Surfaces Opened by Permit. Any individual, firm, partnership or corporation wishing to make an opening in the surface must secure a permit from the Department, and the Contractor shall not allow any person to make an opening unless a duly authorized permit from the Department is presented. Upon the presentation of a duly authorized permit, the Contractor shall allow parties bearing such permits to make openings in the surface. The Contractor shall, if ordered by the Engineer in writing, make, in a manner approved by the Engineer, all necessary repairs to such openings, and such necessary work ordered by the Engineer will be paid for as extra work as provided in Article 109.04.

107.07 Federal Aid Provision. When the United States Government pays all or any portion of the cost of a project, the Federal laws and the rules and regulations made pursuant to such laws must be observed by the Contractor, and the work shall be subject to the inspection of the appropriate Federal agency.

Such inspection shall in no sense make the Federal Government a party to this contract and will in no way interfere with the rights of either party hereunder.

107.08 Sanitary Provisions. The Contractor shall provide and maintain in a neat, sanitary condition such accommodations for the use of the Contractor's employees and Department representatives as may be necessary to comply with the requirements of the State and Local Boards of Health, or of other authorities having jurisdiction.

107.09 Public Convenience and Safety. The Contractor shall notify the Engineer at least three days in advance of the starting of any construction work which might in any way inconvenience or endanger traffic, so arrangements may be made, if necessary, for closing the road and providing suitable detours. The Contractor shall at all times conduct the work in such a manner as to ensure the least obstruction to vehicular and pedestrian traffic. The convenience of the general public and residents along the highway shall be provided for in an adequate and satisfactory manner. When directed by the Engineer, the Contractor shall provide and maintain an acceptable surface aggregate for temporary roads and approaches for access to driveways, houses, buildings, or other property abutting the highway or street being improved. The cost incurred by the Contractor for providing temporary roads will be paid for as extra work as provided in Article 104.02.

The Engineer may require the Contractor to finish a section on which work is in progress before work is started on any additional sections if the opening of such section is essential to public convenience.

No broken pavement, open holes, trenches, barricades, cones, or drums will remain on or adjacent to the traveled way and all lanes shall be opened to traffic during any legal holiday period, except where major bridge construction and/or other roadway reconstruction (excluding patching and resurfacing) requiring overnight lane closures would make it impractical. The legal holidays will include:

New Year's Day
Easter
Memorial Day
Independence Day

Labor Day
Thanksgiving Day
Christmas Day

The length of the holiday period shall vary as follows, depending on the day of the week the legal holiday falls on or is observed.

Day of Holiday	Length of Holiday Period
Sunday	3 p.m. Friday - 12 midnight Sunday
Monday	3 p.m. Friday - 12 midnight Monday
Tuesday	3 p.m. Friday - 12 midnight Tuesday
Wednesday	3 p.m. Tuesday - 12 midnight Wednesday
Thursday	3 p.m. Wednesday - 12 midnight Sunday
Friday	3 p.m. Thursday - 12 midnight Sunday
Saturday	3 p.m. Friday - 12 midnight Sunday

On weekends, excluding holidays, roadways with Average Daily Traffic of 25,000 or greater, all lanes shall be open to traffic from 3:00 P.M. Friday to midnight Sunday except where structure construction or major rehabilitation makes it impractical.

When any construction work is performed on structures over pavements which are open to traffic, the Contractor shall protect the traffic from falling objects and/or materials. The Contractor's method of protection shall be subject to the approval of the Engineer and the cost thereof shall be included in the work involved.

The following vertical and horizontal restrictions shall pertain to roads as defined in the Illinois Highway Code, Article 2, Division 1, Section 2-101 when construction is being performed with the road open to traffic.

In the event that any construction work will create a horizontal or vertical clearance restriction or will cause a reduction in the existing vertical or horizontal clearance on the highway under construction, the Contractor shall notify the Engineer (in writing) one week in advance of performing the work involved.

Notification of horizontal clearance changes shall include those in which the existing lane width is reduced. Notification of vertical clearance changes shall include all vertical changes regardless of the height involved. Notifications shall include both permanent and temporary changes.

In the event that the vertical clearance to any road surface will become less than 14.5 ft (4.4 m), the Contractor (in addition to the aforementioned notifications) shall furnish and install "LOW CLEARANCE" signs and any required advance warning signs according to the current edition of the State of Illinois Manual on Uniform Traffic Control Devices for Streets and Highways, said signs to be placed at locations designated by the Engineer. The designated signs shall be required for permanent clearance changes and for temporary features such as safety nets and false work when the road is open to traffic. When temporary features are to be removed or revised, the Contractor shall again notify the Engineer as provided herein and shall revise the signs to indicate the revised clearance condition.

Except for the cost of providing temporary roads and approaches, all labor, materials, and equipment required to satisfy the conditions stated herein shall be considered as included in the contract bid prices and no extra compensation will be allowed. These requirements shall not reduce the obligations of the Contractor concerning traffic control and responsibility to the public as provided for in the plans and elsewhere in the Specifications or Special Provisions.

107.10 Temporary Railroad Grade Crossing. The Contractor shall make arrangements with the Railroad for the construction, protection, maintenance, and later removal of any temporary grade crossings, across the tracks of the Railroad necessary for the use of the Contractor during the construction of the improvement. The Contractor shall not at any time cross the Railroad's right-of-way or tracks with vehicles or equipment of any type or character, except at such temporary grade crossing as may be constructed according to a separate private crossing agreement, for which the Railroad shall be reimbursed in the full amount of all costs incurred, and as specified herein, or at an existing open public grade crossing. The Contractor shall reimburse the Railroad promptly for the cost of such work, including travel and other expenses involved in furnishing personnel, based on bills rendered monthly or less frequently. The cost of such temporary grade crossing construction, protection, maintenance, and later removal shall be considered as included in the contract unit prices bid for the various items of work involved, and no additional compensation will be allowed.

107.11 Insurance Requirements for Railroad-Highway Crossings. For all railroad-highway grade separation work and selected at-grade crossings as indicated in the contract proposal, the Contractor shall obtain Railroad's Protective Liability and Property Damage Liability Insurance according to the requirements specified hereinafter.

Upon receipt of Certificates of Insurance from the Contractor evidencing the required insurance coverages, the Department will request approval of the insurance and permission to enter upon the Railroad's right-of-way from the Railroad and will advise the Contractor of the approvals. No work shall be performed on the Railroad's right-of-way until the Contractor has received written notice from the Department that the policy has been approved. Failure on the part of the Contractor to secure approval of the insurance shall be just cause for the cancellation of the award and forfeiture of the proposal guaranty to the State, not as a penalty but in payment of liquidated damages sustained as a result of such failure.

The Contractor, with respect to the operations he/she or any subcontractors perform, will be required to carry in the name of and on behalf of each Railroad involved, Railroad Protective Public Liability and Property Damage Liability Insurance (ISO Form) in limits not less than \$2,000,000 combined single limit per occurrence for bodily injury liability and property damage liability with an aggregate limit of \$6,000,000 over the life of the policy. This insurance shall be according to the form as provided for and to be furnished by the Department. Copies of this form will be furnished on request and no substitutes will be accepted. The Contractor shall furnish the Department the original and one certified copy of the policy.

107.12 Protection of Railroad Traffic and Property. All work to be done by the Contractor on the Railroad's right-of-way shall be performed in a manner satisfactory to the Railroad Engineer. The work shall be performed at such times and in such a manner as not to unnecessarily interfere with the movements of trains or traffic upon the tracks of the Railroad. The Contractor shall use all reasonable care and precaution in order to avoid accidents, damage, delay, or interference with the Railroad's trains or other facilities.

The Contractor shall make provisions satisfactory to the Railroad Engineer against disturbing, in any manner, the Railroad embankment, structures, and tracks during construction. If the work to be performed by the Contractor shall, as determined by the Railroad Engineer, weaken or undermine the Railroad embankment, structures, or tracks, then the said work shall be stopped, upon notice so to do, and the forces of the Railroad will proceed with the performance of the work of strengthening the Railroad embankment, structures, or tracks, and the actual cost thereof shall be borne by the Contractor. Should any damage occur to Railroad property as a result of the Contractor's unauthorized or negligent operations, the Railroad may repair such damages and/or perform any work for protection of its property it may deem necessary and the actual cost thereof shall be borne by the Contractor.

The services of Railroad flaggers will be required when the Contractor's operations will encroach on or over the Railroad's right-of-way: (a) during the excavation, placing, and removal of cofferdams or sheeting, driving of foundation piling and placing of concrete footings for piers adjacent to the track; (b) driving of pile bents adjacent to the track; (c) construction of the permanent structure including erection and removal of falsework, bracing, or forms over or adjacent to the track; (d) transporting material or equipment across the track; (e) any operations involving direct interference with and/or coming in the close vicinity of power lines or Railroad signal and communication lines, underground cables, fuel oil facilities, or pipe lines which might result in fire or damage to such facilities to endanger Railroad operations, or to endanger the public in the transacting of business on Railroad right-of-way; (f) fouling of operating clearances or reasonable probability of accidental hazard to Railroad traffic; (g) during removal of portions of existing structures immediately over or adjacent to a track; and (h) at all other times when the Railroad Engineer has determined conditions require such protection and the Engineer has determined conditions warrant such protection and has approved the request.

As soon as possible, the Contractor shall furnish the Railroad with the approximate dates flagging services are needed. The approximate date of initiation of flagging services shall be at least 30 calendar days after notification. The Contractor shall also notify the Railroad at least 48 hours in advance of the actual initiation and termination of flagging services.

The Contractor shall pay the costs of Railroad flaggers required for transporting material or equipment across the track. These costs shall be considered as included in the contract unit prices bid for the various items of work involved. All other Railroad flagger costs will be incurred by the Department.

When the contract includes Railroad grade separation work, the Contractor shall conduct work so as to cause no temporary or permanent reduction of the existing vertical clearance over the top of high rail or temporary or permanent obstruction in an area affording a minimum horizontal clearance of 8.5 ft (2.60 m) on each side of the centerline of any track, measured at right angles thereto. No materials, supplies, or equipment shall be stored within 15 ft (4.5 m) of the centerline of any track, measured at right angles thereto. If lesser clearances than the above are required for any part of the work, the Contractor shall secure written authorization from the Railroad Engineer for such lesser clearances not less than five days in advance of the start of that part of the work, provided permission has been obtained from the Illinois Commerce Commission. The cost of conforming to these requirements shall be

considered as included in the contract unit prices bid for the various items of work involved, and no additional compensation will be allowed.

107.13 Bridges Over Navigable Waters. All work on navigable waters shall be so conducted that free navigation of the waterways will not be interfered with and that the existing navigable depths will not be impaired, except as allowed by permit issued by the authority having jurisdiction over the navigable waters.

107.14 Maintenance of Traffic. When work zone traffic control is required along the route under construction, or when any section of road is closed for construction operations of any type, or when any section of the road is opened to traffic prior to completion of all work, the Contractor shall protect the workers and provide for safe and convenient public travel by providing adequate traffic control. The traffic control shall conform to the Traffic Control Plan, included in the contract, and to the requirements of Section 701.

107.15 Dirt on Pavement or Structures. Where the Contractor's equipment is operated on any portion of the pavement or structures used by traffic on or adjacent to the section under construction, the Contractor shall clean the pavement of all dirt and debris at the end of each day's operations, and at other times as directed by the Engineer.

The Contractor shall furnish, erect and maintain "SLIPPERY WHEN WET" signs at such locations, when required during wet weather.

The cost of this work shall be included in the unit prices bid and no additional compensation will be allowed.

107.16 Equipment on Pavement and Structures. The pavement and structures on or adjacent to the work shall be protected, in a manner satisfactory to the Engineer, from damage by lugs or cleats on treads or wheels of equipment. All equipment used in the prosecution of the work shall comply with the legal loading limits established by the statutes of the State of Illinois when moved over or operated on any pavement or structure unless permission in writing has been issued by the Engineer. Before using any equipment which may exceed the legal loading, the Contractor shall secure a permit, allowing ample time for making an analysis of stresses to determine whether or not the proposed loading would be within safe limits. The Department will not be responsible for any delay in construction operations or for any costs incurred by the Contractor as a result of compliance with the above requirements.

107.17 Use of Explosives. When the use of explosives is necessary for the prosecution of the work, the Contractor shall exercise the utmost care not to endanger life or property, including new work. The Contractor shall be responsible for all damage resulting from the use of explosives.

All explosives shall be stored in a secure manner in compliance with all laws and ordinances, and all such storage places shall be clearly marked. Where no local laws or ordinances apply, storage shall be provided satisfactory to the Engineer and, in general, not closer than 1000 ft (300 m) from the road or from any building or camping area or place of human occupancy.

The Contractor shall notify each public utility company having structures in proximity to the site of work of the intention to use explosives. Such notice shall be given sufficiently in advance to enable the companies to take such steps as they deem necessary to protect their property from injury.

107.18 Use of Fire Hydrants. If the Contractor desires to use water from hydrants, the Contractor shall make application to the proper authorities, and shall conform to the municipal ordinances, rules, or regulations concerning their use.

Fire hydrants shall be accessible at all times to the Fire Department. No material or other obstructions shall be placed closer to a fire hydrant than permitted by municipal ordinances, rules, or regulations, or within 5 ft (1.5 m) of a fire hydrant, in the absence of such ordinances, rules, or regulations.

107.19 Unexpected Regulated Substances. If the Contractor encounters or exposes during construction any abnormal condition which may indicate the presence of a regulated substance, work in this area shall be immediately discontinued and the Engineer shall be notified. A regulated substance is a hazardous substance, special waste or petroleum or any fraction thereof, as those terms are defined in the Illinois Compiled Statutes.

Abnormal conditions include, but will not be limited to, the following: presence of underground storage tanks or barrels; discolored earth, metal, wood, etc.; visible fumes; obnoxious or unusual odors; excessively hot earth; smoke; or any other condition which appears abnormal and could be a possible indicator of regulated substances. The conditions shall be treated with extraordinary caution. Appropriate action shall be taken to ensure public and employee safety.

The Contractor's operation shall not resume until directed by the Engineer. The Department may contact the IEMA and/or the IEPA. Removal and disposal operations shall be coordinated with the removal and disposal operations of contaminated soil, groundwater and/or an UST shall be according to Section 669.

Should the disposition of waste material require special procedures by certified personnel, the Department will make arrangements with qualified persons to dispose of the material. If the Department provides for removal and disposal operations by forces other than the Contractor's and arranges for the Contractor to pay all costs in connection therewith, the Contractor will be reimbursed according to Article 109.05.

Disposition of the regulated substances shall be made according to the requirements and regulations of the IEPA. Any waste generated as a special waste or hazardous waste shall be manifested off-site using the Department's county generator number. An authorized representative of the Department will sign all manifests for the disposal of the contaminated material and confirm the Contractor's transported volume. Any waste generated as a non-special waste may be disposed of off-site at a facility permitted by the IEPA without a manifest, a special waste transporter, and a generator number.

The Contractor shall abide with the Response Action Contractor Indemnification Act of the Illinois Compiled Statutes.

When the Contractor encounters unexpected regulated substances due to the presence of unknown utilities, Article 105.07(b) shall apply; otherwise, if the Engineer does not direct a resumption of operations, the provisions of Article 108.07 shall apply. When the Contractor performs necessary work required to dispose of these materials, payment will be made at the contract unit price for items applicable to such work, or payment will be made according to Article 104.02.

107.20 Protection and Restoration of Property. If corporate or private property interferes with the work, the Contractor shall notify, in writing, the owners of such property, advising them of the nature of the interference and shall arrange to cooperate with them for the protection or disposition of such property. The Contractor shall furnish the Engineer with copies of such notifications and with copies of any agreements between the Contractor and the property owners concerning such protection or disposition.

The Contractor shall take all necessary precautions for the protection of corporate or private property, such as walls and foundations of buildings, vaults, underground structures of public utilities, underground drainage facilities, overhead structures of public utilities, trees, shrubbery, crops, and fences contiguous to the work, for which the contract does not provide for removal or specify precautions. The Contractor shall protect and carefully preserve all official survey monuments, property marks, section markers, and Geological Survey Monuments, or other similar monuments, until the owner, or an authorized surveyor or agent has witnessed or otherwise referenced their location or relocation. The Contractor shall notify the Engineer of the presence of any such survey or property monuments as soon as they are discovered.

The Contractor shall be responsible for the damage or destruction of property of any character resulting from neglect, misconduct, or omission in his/her manner or method of execution or nonexecution of the work, or caused by defective work or the use of unsatisfactory materials, and such responsibility shall not be released until the work shall have been completed and accepted and the requirements of the Specifications complied with.

Whenever public or private property is so damaged or destroyed, the Contractor shall, at no additional cost to the Department, restore such property to a condition equal to that existing before such damage or injury was done by repairing, rebuilding, or replacing it as may be directed, or the Contractor shall otherwise make good such damage or destruction in an acceptable manner. If the Contractor fails to do so, the Engineer may, after the expiration of a period of 48 hours after giving the Contractor notice in writing, proceed to repair, rebuild, or otherwise restore such property as may be deemed necessary, and the cost thereof will be deducted from any compensation due, or which may become due, the Contractor under this or any other contract between the Department and the Contractor.

The Contractor shall remove all mailboxes within the limits of construction which interfere with construction operations and shall erect them at temporary locations.

As soon as construction operations permit, the Contractor shall set the mailboxes at their permanent locations. This work shall be performed as directed by the Engineer. The Contractor shall replace, at no additional cost to the Department, any mailbox or post which has been damaged by the Contractor's operations.

The cost of all materials required and all labor necessary to comply with the above Provisions will not be paid for separately, but shall be considered as included in the unit bid prices of the contract, and no additional compensation will be allowed.

107.21 Protection and Preservation of Aboriginal Records and Antiquities. The Contractor shall take reasonable precautions to avoid disturbing aboriginal records and antiquities of archaeological, paleontological, or historical significance. No objects of this nature shall be disturbed without written permission of the Engineer. When such objects are uncovered unexpectedly, the Contractor shall notify the Engineer of their presence and shall not disturb them until written permission to do so is granted.

If it is determined by the Engineer, in consultation with the Illinois Historic Preservation Agency, that exploration or excavation of aboriginal records or antiquities on land owned or leased by the State is necessary to avoid loss, the Contractor shall cooperate in the salvage work attendant to preservation. If the Engineer determines the salvage work will delay the Contractor's work, an appropriate extension of contract time will be granted.

107.22 Approval of Proposed Borrow Areas, Use Areas, and/or Waste Areas. All proposed borrow areas, including commercial borrow areas; use areas, including, but not limited to temporary access roads, detours, runarounds, plant sites, and staging and storage areas; and/or waste areas are to be designated by the Contractor to the Engineer and approved prior to their use. Such areas outside the State of Illinois shall be evaluated, at no additional cost to the Department, according to the requirements of the state in which the area lies; and approval by the authority within that state having jurisdiction for such areas shall be forwarded to the Engineer. Such areas within Illinois shall be evaluated as described herein.

A location map delineating the proposed borrow area, use area, and/or waste area shall be submitted to the Engineer for approval along with an agreement from the property owner granting the Department permission to enter the property and conduct cultural and biological resource reconnaissance surveys of the site for archaeological resources, threatened or endangered species or their designated essential habitat, wetlands, prairies, and savannahs. The type of location map submitted shall be a topographic map, a plat map, or a 7.5 minute quadrangle map. Submittals shall include the intended use of the site and provide sufficient detail for the Engineer to determine the extent of impacts to the site. The Engineer will initiate cultural and biological resource reconnaissance surveys of the site, as necessary, at no cost to the Contractor. The Engineer will advise the Contractor of the expected time required to complete all surveys. If the proposed area is within 150 ft (45 m) of the highway right-of-way, a topographic map of the proposed site will be required as specified in Article 204.02.

- (a) **Archaeological Resources.** If potentially significant archaeological resources are identified, the Contractor shall have the option of choosing another site or paying for additional archaeological testing. If the Contractor chooses the option of additional testing, the Engineer will obtain a time and cost proposal for the Contractor's approval prior to the testing work being done. The archaeological testing may result in two possible conclusions:

- (1) Results of the tests show that no further archaeological work is warranted and the site is approved, or
- (2) Results of the test indicate that data recovery is warranted and the Contractor shall have the option of selecting another location or paying for the salvage operations.

If the area is approved as a borrow area, use area, and/or waste area, the Contractor shall obtain as part of the agreement with the property owner, the release of ownership of any artifacts found on the site. The agreement shall also provide that such artifacts will become the property of the State of Illinois.

The Contractor shall furnish copies of the proposed and final agreement to the Engineer for approval.

In the event hydraulic fill or commercial material from rock quarries, waste material, etc., is to be used, a reconnaissance survey for archaeological resources will be conducted only if disturbance of previously undisturbed areas is required to provide such material.

- (b) Wetlands. If the results of the biological resource reconnaissance survey indicate wetlands may be adversely affected by the proposed borrow area, use area, and/or waste area, the Engineer will not approve the area for use unless the Contractor provides documentation of concurrence from the Illinois Department of Natural Resources in the following:
 - (1) There is no feasible alternative to the proposed action which adversely affects wetlands, and
 - (2) The proposal for use of the area includes all practicable measures to minimize adverse impacts to the wetland and to provide appropriate compensation for any unavoidable adverse impacts.

In addition, when a proposed borrow area, use area and/or waste area may involve the discharge of material into wetlands, the Engineer will not approve the area for use unless the Contractor provides evidence of necessary permit approval from the U. S. Army Corps of Engineers.

- (c) Threatened and Endangered Species. If the results of the biological resource reconnaissance survey indicate threatened or endangered species or their designated essential habitat may be affected by the proposed borrow area, use area, and/or waste area, the Engineer will not approve the area for use unless the Contractor provides evidence of compliance with the consultation requirements of the Illinois Endangered Species Protection Act and has received from the Illinois Department of Natural Resources one of the following findings.
 - (1) The action may promote the conservation of a listed species or its essential habitat, or

- (2) The action is not likely to jeopardize a listed species or its essential habitat.

If the Department of Natural Resources advises the proposed action may be likely to jeopardize a listed species or its essential habitat, the Engineer will not approve the site.

- (d) Forested Areas, Prairies, and Savannahs. If the results of the biological resource reconnaissance survey indicate that forested areas, prairies, or savannahs may be adversely affected by the proposed borrow area, use area, and/or waste area, the Engineer will recommend the Contractor minimize harm to such areas by selecting alternative sites, where practical, and by providing replacement plantings of trees or prairie vegetation, as appropriate. Such plantings may be recommended for the borrow area, use area, and/or waste area, subject to the approval of the property owner, or on highway right-of-way.

107.23 Protection of Streams, Lakes, Reservoirs, Natural Areas, Wetlands, Prairie Areas, Savannahs, and Endangered and Threatened Species. The Contractor shall take sufficient precautions to prevent pollution of streams, lakes, reservoirs, and wetlands with fuels, oils, bitumens, calcium chloride, or other harmful materials. The Contractor shall conduct and schedule operations so as to avoid or minimize siltation of streams, lakes, reservoirs, and wetlands.

The Contractor shall not disturb designated natural areas, wetlands, identified locations where State or Federal-listed endangered or threatened species are known to occur, or areas that have been designated as essential habitat for such species, or prairie or Savannah areas where the Department has made commitments for protection of these locations/areas. Also, if previously unidentified natural areas, wetlands, prairies, savannahs, or areas or locations suspected of containing protected species are identified during construction, the Contractor shall not disturb them unless written permission to do so is granted by the Engineer.

If the Engineer determines measures are necessary to mitigate project effects on natural areas, wetlands, prairies, savannahs, protected species, or essential habitat located on land owned or leased by the State, the Contractor shall cooperate in accomplishing these measures.

107.24 Forest Protection. In carrying out work within or adjacent to State or National Forests, the Contractor shall comply with all regulations of the State Fire Marshall, Conservation Commission, Forestry Department, or other authority having jurisdiction governing the protection of forests and the carrying out of work within forests, and shall observe all sanitary laws and regulations with respect to the performance of work in the forest areas. The Contractor shall keep the areas in an orderly condition; dispose of all refuse; and obtain permits for the construction and maintenance of all construction camps, stores, warehouses, residences, latrines, cesspools, septic tanks, and other structures according to the requirements of the Forest Supervisor.

The Contractor shall take all reasonable precaution to prevent and suppress forest fires and shall require employees and subcontractors, both independently and at the request of Forest officials, to do all within their power to prevent and suppress

and to assist in preventing and suppressing forest fires and to make every possible effort to notify a Forest official at the earliest possible moment of the location and extent of any fire seen by them.

107.25 Protection and Restoration of Traffic Signs. All traffic signs within the limits of construction which interfere with construction operations or which are obscured by or otherwise interfered with by the construction operations to the extent that they no longer have the desired effect on traffic, shall be removed by the Contractor when directed by the Engineer. Any such signs the Engineer determines are essential to the safe and orderly flow of traffic shall be re-erected immediately by the Contractor at temporary locations in a manner approved by the Engineer.

The Contractor shall maintain the signs in a straight and neat condition for the duration of the temporary mounting. Signs which are not to be re-erected immediately shall be stored off the ground in a covered area. As soon as construction operations permit, the signs shall be replaced at their permanent locations to the satisfaction of the Engineer.

Any sign or post which the Engineer determines has been damaged due to the construction operation or while in storage shall be replaced by the Contractor.

The costs of all materials required and all labor necessary to comply with this Provision will be considered as included in the unit bid prices of the contract and no additional compensation will be allowed.

107.26 Indemnification. To the fullest extent permitted by law, the Contractor shall be responsible for any and all injuries to persons or damages to property due to the activities of the Contractor, subcontractors, suppliers, agents, or employees arising out of or resulting from performance of the contract, or any activity in connection therewith. The Contractor shall indemnify and hold harmless the Department, its officers, employees, and agents from any and all claims, lawsuits, actions, costs, and fees (including reasonable attorney fees and expenses) of every nature or description, arising from, growing out of, or connected with the work, or on account of or in consequence of any neglect in safeguarding the work or on account of or in consequence of using unacceptable materials in constructing the work or because of any act or omission, neglect, or misconduct of the Contractor, its officers, employees, agents, its subcontractor, or subcontractors, anyone directly or indirectly employed by them, and/or anyone for whose acts they may be liable or because of any claims or amount recovered by reason of any infringement of any patent, trademark, or copyright or by reason of the violation of any law, ordinance, order or decree. This obligation is binding on the Contractor without regard to whether or not such claim, damage, loss, or expense is caused in part by the act, omission, or negligence of the Department or its officers, employees, or agents.

In claims against the Department or any individual indemnified under this Article by an employee of the Contractor, a subcontractor, anyone directly or indirectly employed by them, or anyone for whose acts they may be liable, the indemnification herein shall not be limited by a limitation on amount or type of damages payable by or for the Contractor or subcontractor under any employee benefits act including but not limited to the Worker's Compensation Act.

In the event any such claim, lawsuit, or action is asserted, any such money due the Contractor under and by virtue of the contract as shall be deemed necessary by the Department for the payment thereof, may be retained by the Department for said purpose, or in case no money or insufficient money is due to satisfy such claim, lawsuit, or action, the Contractor's Surety shall remain liable for any payment therefore until any such lawsuit, action, or claim has been settled or has been fully judicially determined and satisfied.

No inspection by the Department, its employees or agents shall be deemed a waiver by the Department of full compliance with the requirements of the contract. This indemnification shall not be limited by the required minimum insurance coverages provided in the contract.

107.27 Insurance. The Contractor shall obtain and thereafter keep in force the following insurance coverages provided by insurance companies acceptable to the Department and authorized to transact business under the laws of the State of Illinois. The insurance companies providing coverage shall be rated in the Best's Key Rating Guide. The Department will accept companies with a rating not lower than B+ provided the financial size category is VII or larger. Companies rated A- or better shall have a financial size category of not less than VI. Coverage limits shall be written at not less than the minimum specified in this Article. Higher minimum limits and additional coverage may be specified by a special provision elsewhere in the contract. Whether stated in this Article or elsewhere, the Department does not warrant the adequacy of the types of insurance coverage or the limits of liability specified.

(a) Workers Compensation and Employers Liability.

- (1) Workers compensation shall be provided according to the provisions of the Illinois Worker's Compensation Act, as amended. Notwithstanding the rating and financial size categories stated in this Article, coverage may be provided by a group self-insurer authorized in Section 4(a) of the Act and approved pursuant to the rules of the Illinois Department of Insurance.

(2) Employers Liability.

- | | |
|--------------------------|-----------|
| a. Each Accident | \$500,000 |
| b. Disease-policy limit | \$500,000 |
| c. Disease-each employee | \$500,000 |

- (b) Commercial General Liability. Required liability insurance coverage shall be written in the occurrence form and shall provide coverage for operations of the Contractor; operations of subcontractors (contingent or protective liability); completed operations; broad form property damage and hazards of explosion, collapse and underground; and contractual liability. The general aggregate limit shall be endorsed on a per project basis.

- | | |
|-----------------------------------|-------------|
| (1) General Aggregate Limit | \$2,000,000 |
| (2) Products-Completed Operations | |
| Aggregate Limit | \$2,000,000 |
| (3) Each Occurrence Limit | \$1,000,000 |

The coverage shall provide by an endorsement in the appropriate manner and form, the Department, its officers, and employees shall be named as additional insureds with respect to the policies and any umbrella excess liability coverage for occurrences arising in whole or in part out of the work and operations performed. The Department may accept a separate owner's protective liability policy in lieu of the Department, its officers, and employees being insureds on the Contractor's policies.

- (c) Commercial Automobile Liability. The policy shall cover owned, non-owned, and hired vehicles.

Bodily Injury & Property Damage	
Liability Limit Each Occurrence	\$1,000,000

- (d) Umbrella Liability. Any policy shall provide excess limits over and above the other insurance limits stated in this Article. The Contractor may purchase insurance for the full limits required or by a combination of primary policies for lesser limits and remaining limits provided by the umbrella policy.

All insurance shall remain in force during the period covering occurrences happening on or after the effective date and remain in effect during performance of the work and at all times thereafter when the Contractor may be correcting, removing, or replacing defective work until notification of the date of final inspection. Termination or refusal to renew shall not be made without 30 days prior written notice to the Department by the insurer and the policies shall be endorsed so as to remove any language restricting or limiting liability concerning this obligation.

Certified copies of the original policies or certificate(s) of insurance by the insurer(s) issuing the policies and endorsements setting forth the coverage, limits, and endorsements shall be filed with the Department before the Department will execute the contract. A certificate of insurance shall include a statement "the coverage and limits conform to the minimums required by Article 107.27 of the Standard Specifications for Road and Bridge Construction". Any exception or deviation shall be brought to the attention of the Department for a ruling of acceptability. In no event shall any failure of the Department to receive policies or certificates or to demand receipt be construed as a waiver of the Contractor's obligation to obtain and keep in force the required insurance.

All costs for insurance as specified herein will be considered as included in the cost of the contract. The Contractor shall, at his/her expense and risk of delay, cease operations if the insurance required is terminated or reduced below the required amounts of coverage. Coverage in the minimum amounts set forth herein shall not

be construed to relieve the Contractor from his/her obligation to indemnify in excess of the coverage according to the contract.

107.28 Contractor Safety Responsibility. Nothing in this contract or the contracts between the Department and any construction engineering consultant(s) is intended or shall be construed, unless otherwise expressly stated, to reduce the responsibility of the Contractor, a subcontractor, anyone directly or indirectly employed by them or anyone for whose acts they may be liable, from full and complete supervision and achievement of work place safety. Any inspection of the work conducted by the Department, the construction engineering consultant(s), and the officers and employees of any of them, whether notice of the results thereof is provided to anyone or not provided to anyone, shall neither establish any duty on their parts nor create any expectation of a duty to anyone, including but not limited to third parties, regarding work place safety.

In order to insure this and other duties of the Contractor certain indemnification and insurance is required by the contract. Additionally, the Contractor guarantees to the Department a safe work place shall be provided for all employees of the Contractor and each of its subcontractors. There shall be no violation by the Contractor, a subcontractor, anyone directly or indirectly employed by them, or anyone for whose acts they may be liable of the applicable standards of the Occupational Safety and Health Act, any other work place safety act of this State, or other work place safety requirement of the Federal Highway Administration if the contract is funded in part with federal funds. The Contractor agrees to require this work place safety guarantee of all subcontractors according to Article 108.01, and expressly to require the Department to be a third party beneficiary of each guarantee.

107.29 Opening of Section of Highway to Traffic. The work under construction shall not be opened to traffic until authorized by the Engineer in writing. The Department reserves the right to use and to open to traffic any portion of the work before completion of the entire work when the Engineer determines that an early opening is in the interest of the public or when the Contractor has failed to prosecute the work continuously and efficiently. Such opening shall not be construed as an acceptance of the work, or any part of it, or cause for the Department to incur any liability to the Contractor for any additional costs, except as provided in Article 107.30 or otherwise expressly provided in the contract.

Whenever the Contractor is required to open to traffic all of the work or any portion thereof according to the authorization of the Engineer given herein, the Contractor shall conduct the remainder of the construction operations so as to cause the least obstruction to traffic and according to the traffic control plan established in the contract or by the Engineer.

107.30 Contractor's Responsibility for Work. Except as otherwise provided in this Article, all work of the contract, including work added to the contract, shall be under the charge and care of the Contractor. The Contractor shall protect and maintain the work until the date of final inspection is provided in writing to the Contractor, by the Department according to Article 105.13. The Contractor shall assume the sole responsibility for risk of loss to the work from or by any cause whatsoever, without regard to its state of completion. The Contractor shall rebuild, repair, restore, replace, and make good all lost, destroyed, or damaged work to the condition required by the contract and shall bear all the expense and costs to do so,

except when the Engineer determines the loss, destruction or damage to the work to be caused by a cataclysmic event, an act of the public enemy, or an act of a governmental authority. This exception shall not apply should the Engineer determine that the loss, destruction, or damage resulted from the Contractor's failure to take reasonable precautions or to exercise sound engineering and construction practices while conducting the work. The Contractor and Department understand and agree that the definition of what constitutes a cataclysmic event cannot be written with precision, and that application of this exception can be the subject of dispute. Therefore, the Contractor and Department agree that the Engineer will determine the occurrence of a cataclysmic event, the eligibility for reimbursement, and the expenses and costs to be reimbursed in accordance with this exception to the Contractor's responsibility for the work. All determinations of the Engineer shall be final. The Contractor shall have no entitlement to reimbursement, under this or any other article or provision of the contract, for any or all expenses or costs in the absence of the affirmative determination by the Engineer as to coverage by this exception and the amounts eligible for reimbursement, and the Contractor agrees that the application or denial of the application of this exception shall not be cause for action in the Illinois Court of Claims and hereby waives the same.

The provisions of this Article shall not apply to damage caused by traffic on sections not constructed under traffic but, opened to traffic by written order of the Engineer according to Article 107.29 to serve the public interest unless the damage was caused in whole or in part by the Contractor's operations or negligence. If the Contractor has failed to prosecute the work continuously and efficiently or, if the Contractor has failed to prosecute work appurtenant to the roadway such as shoulders, drainage structures, or other features of the work not directly related to safe flow of traffic, and the Engineer orders the work opened to traffic, the Contractor shall not be relieved of responsibility for the work pursuant to this Article. On sections constructed under traffic, the provisions of this Article shall not apply to damage caused by traffic to facilities existing in the roadway prior to the execution of the contract, to damage caused by traffic to existing highway facilities that are not subject to the work of the contract, or to damage to portions of the work that have been approved by the Engineer according to this Article, unless the damage was caused in whole or in part by the Contractor's operations or negligence or the contract special provisions require the Contractor to protect and maintain existing facilities. For purposes of this Article, sections constructed under traffic shall mean construction or reconstruction on existing roadways and structures where traffic is maintained in whole or in part through and/or within the contract limits by staged construction, lane closures, or other traffic control.

The Contractor may request in writing that the Department assume responsibility to protect and maintain any portion of the work that has been completed in all respects with the requirements of the contract subject to the approval of the Engineer. Portions of work that the Contractor may request the Engineer to approve under this article for relief from maintenance and protection are limited to the following.

- (a) Not less than a one-quarter mile continuous length of roadway including shoulders, drainage control facilities, planned roadway protection work, lighting and any required traffic control and access facilities.
- (b) A bridge, a box culvert, or a retaining-wall that is not part of a one-quarter mile of continuous roadway.

- (c) A full intersection or interchange including all shoulders, drainage control facilities, planned roadway protection work, lighting and any required traffic control, and access facilities.
- (d) A full intersection traffic control light system or a one-quarter mile length highway lighting system not eligible as part of a one-quarter mile continuous roadway or full intersection or interchange.

When the road is open to traffic, this request may include, subject to the approval of the Engineer, safety-related hardware items such as impact attenuators, signs, markers, and light standards having traversable, frangible, or breakaway bases; guardrail and terminal sections; and bridge railing at each separate location. Any approval granted may alter or limit the part of the work subject to the approval. After the date of written approval, the Contractor shall be relieved of the responsibility to protect and maintain the work subject to the approval and shall not be responsible for the correction of any damage or the performance of any maintenance work in the areas subject to the approval, except that caused in whole or in part by Contractor operations within the limits of the project or negligence. When damage to the work subject to the approval occurs and it is determined the Contractor is not responsible, the Engineer may order repairs to the work by the Contractor and payment will be made according to Article 109.04. Any approval granted under this Article shall neither constitute final acceptance of any of the work nor be construed to be substantial completion thereof, and the work covered by any approval shall continue to be subject to final inspection and acceptance in accordance with the terms of the contract. Repairs to work subject to the approval required due to defective materials or workmanship or caused in whole or in part by Contractor operations or negligence, shall be performed at no additional cost to the Department.

During periods of suspension in accordance with Article 108.07 or other discontinuance of work from any cause whatever, the Contractor shall continue to be responsible for the work as provided in this Article and shall take such precautions as may be necessary to prevent damage to the work, provide for normal drainage and shall erect any necessary temporary structures, signs, or other facilities at his/her expense, except as otherwise provided in Article 108.07. During such period of suspension or discontinuance of work, the Contractor shall properly and continuously maintain, in an acceptable growing condition, all living material in newly established plantings, seedings, and soddings furnished under his/her contract, and shall take adequate precautions to protect new tree growth and other important vegetative growth against injury.

Additional responsibilities and maintenance for electrical work shall be according to Articles 801.11 and 801.12.

107.31 Contractor's Responsibility for Utility Property and Services. At points where the Contractor's operations are adjacent to properties or facilities of the Railroad or utility companies, or are adjacent to other property, damage to which might result in considerable expense, loss, or inconvenience, work shall not be commenced until all arrangements necessary for the protection thereof have been made.

The Contractor shall cooperate with the owners of any utilities in their removal and rearrangement operations so work may progress in a reasonable manner, duplication of rearrangement work may be reduced to a minimum, and services rendered by those parties will not be unnecessarily interrupted. In the event of interruption of utility services as a result of accidental breakage or as a result of being exposed or unsupported, the Contractor shall promptly notify the proper authority and shall cooperate with the said authority in the restoration of service. If water service is interrupted, repair work shall be continuous until the service is restored. No work shall be undertaken around fire hydrants until provisions for continued service have been approved by the local fire authority.

Within the State of Illinois, a State-Wide One Call Notice System has been established for notifying utilities. Outside the city limits of the City of Chicago, the system is known as the Joint Utility Locating Information for Excavators (JULIE) System. Within the city limits of the City of Chicago the system is known as DIGGER. All utility companies and municipalities which have buried utility facilities in the State of Illinois are a part of this system.

The Contractor shall call JULIE (800-892-0123) or DIGGER (312-744-7000), a minimum of 48 hours in advance of work being done in the area, and they will notify all member utility companies involved their respective utility should be located. The political name of the township where the work is located, as shown on the location map, along with other location information such as land section and quarter section shall be given.

For utilities which are not members of JULIE or DIGGER, the Contractor shall contact the owners directly. The plan general notes will indicate which utilities are not members of JULIE or DIGGER.

The type of utility and color used for marking are shown in the following table.

<u>Utility Service</u>	<u>Color</u>
Electric Power, Distribution and Transmission	Safety Red
Municipal Electric Systems	Safety Red
Gas Distribution and Transmission	High Visibility Safety Yellow
Oil Distribution and Transmission	High Visibility Safety Yellow
Telephone and Telegraph System	Safety Alert Orange
Community Antenna Television Systems	Safety Alert Orange
Water Systems	Safety Precaution Blue
Sewer Systems	Safety Green
Non-Potable Water and Slurry Lines	Safety Purple
Temporary Survey	Safety Pink
Proposed Excavation	Safety White (Black when snow is on the ground)

107.32 Furnishing Right-of-Way. The Department will make available all necessary rights-of-way in advance of construction. Any exceptions will be indicated in the contract.

Any temporary easement area shall be used only for the purpose of highway construction for which it was obtained. If the Contractor wishes to use a temporary easement area for such things as equipment and material storage, he/she shall obtain written approval from the property owner involved and present the written approval to the Engineer before using.

107.33 Personal Liability of Public Officials. In carrying out any of the Provisions of this contract or in exercising any power or authority granted to the Engineer thereby, there shall be no personal liability upon the Engineer or authorized representative, it being understood in such matters they act as agents and representatives of the State. By entering into this contract with the Department, the Contractor covenants and agrees it shall neither commence nor prosecute any action or suit whatsoever against the officers or employees of the Department for any action or omission done or not done in the course of their administration of this contract. The Contractor agrees to pay all attorney fees and all costs incurred by the Department, its officers, and employees on account of action or suit in violation of this Article.

107.34 No Waiver of Legal Rights. The Department shall not be precluded or estopped by final acceptance or final payment, or any measurement, estimate, or certificate made either before or after the completion and acceptance of the work and payment therefore, from showing the true amount and character of the work performed and materials furnished by the Contractor, nor from showing any such measurement, estimate, or certificate is untrue or is incorrectly made; nor the work or materials do not in fact conform to the contract. The Department shall not be precluded or estopped, by final acceptance, final payment, or any measurement, estimate, or certificate and payment in accordance therewith, from recovering from the Contractor or its sureties, or both, such overpayment and damage as it may sustain by reason of the Contractor's failure to comply with the terms of the contract.

A waiver on the part of the Department of any right under the contract or of a breach of any part of the contract shall not be held to be a waiver of any other or subsequent breach or right to enforce any provision of the contract.

107.35 Construction Noise Restrictions. All engines and engine driven equipment used for hauling or construction shall be equipped with an adequate muffler in constant operation and properly maintained to prevent excessive or unusual noise.

Construction within 1000 ft (300 m) of an occupied residence, motel, hospital, or similar receptor shall be confined to the period beginning at 7 a.m. and ending at 10:00 p.m. This time regulation shall not apply to sawing contraction joints, as required in Article 420.05, maintenance or operation of safety and traffic control devices such as barricades, signs, and lighting, or to construction of an emergency nature.

Any machine or device or part thereof which is regulated by or becomes regulated by Federal or State of Illinois noise standards shall conform to those standards. Such equipment shall be operated as designated above.

Requests to modify or deviate from these requirements shall be submitted in writing by the Contractor and must be approved in writing by the Engineer.

107.36 Dust Control. The Contractor shall be responsible for controlling the dust and air-borne dirt generated by his/her construction activities.

The Engineer may require the implementation of dust control procedures if wind and dry soil conditions reduce visibility on adjacent roads and property. Concerns for health and safety to the public using adjacent facilities will be grounds for the Engineer to request implementation of a dust control plan.

When circumstances warrant, and in the non-attainment areas and "Maintenance" areas, a specific dust control plan shall be developed. Non-attainment and "Maintenance" areas will be published as a special notice in the Service Bulletin. The Contractor and the Department shall meet to review the nature and extent of dust generating activities and cooperatively develop specific types of control techniques appropriate to that specific situation. Sample techniques that may warrant consideration include the following measures.

- (a) Minimize track out of soil onto nearby publicly traveled roads.
- (b) Reduce vehicle speed on unpaved surfaces.
- (c) Cover haul vehicles.
- (d) Apply chemical dust suppressants or water to exposed surfaces, particularly to surfaces on which construction vehicles travel.

Dust control measures as indicated in the Dust Control Plan, or as directed by the Engineer, shall be readily available for use on the project site.

The cost of this work shall be included in the unit prices bid and no additional compensation will be allowed.

SECTION 108. PROSECUTION AND PROGRESS

108.01 Subcontracting. The Contractor shall not subcontract, sell, transfer, assign, or otherwise dispose of the contract or any portion thereof, or of his/her right, title, or interest therein, without written consent of the Engineer. Notwithstanding consent to subcontract approved by the Engineer, the Contractor shall perform with the Contractor's own organization, work amounting to not less than 50 percent of the total contract cost, and with materials purchased or produced by the Contractor. Items designated in the contract as "specialty items" may be performed by subcontract and the cost of any such specialty items so performed by subcontract may be deducted from the total cost before computing the amount of work required to be performed by the Contractor with his/her own organization. "Specialty items" will be those items so designated on the Summary of Quantities included in the plans.

The Engineer may request the Contractor provide proof that any proposed subcontractor has the experience, ability, and equipment the work requires.

No subcontracts, or assignments of payments due or to become due, shall in any case release the Contractor or surety of liability under the contract and bonds. All transactions of the Engineer shall be with the Contractor. The Contractor shall have a representative on the job at all times when either contract or subcontract work is being performed.

All requests to subcontract shall contain a certification that the subcontract agreement exists in writing, that the subcontract incorporates by reference the terms and conditions of the contract, and that the subcontract incorporates fully therein the required Federal and State Equal Employment Opportunity provisions and labor Compliance provisions, including the contract wage requirements. The Contractor shall permit Department or Federal representatives to examine the subcontract agreements upon notice.

The Engineer may order the Contractor to remove a subcontractor who does not perform satisfactory work or does not possess the integrity, experience, ability, and equipment the work requires in accordance with the terms and conditions of this contract. The Contractor shall comply at once and shall not employ the subcontractor for any further work under this contract.

All subcontractors shall be registered with the Department as a condition for approval to perform work on the contract.

108.02 Progress Schedule. After the award of the contract and prior to starting work, the Contractor shall submit to the Engineer a satisfactory progress schedule or critical path schedule which shall show the proposed sequence of work, and how the Contractor proposes to complete the various items of work within the number of working days set up in the contract or on or before the completion date specified in the contract.

This schedule shall be used as a basis for establishing the controlling item of construction operations and for checking the progress of the work. The controlling item shall be defined as the item which must be completed either partially or completely to permit continuation of progress. It shall be the responsibility of the Contractor to show the intended rate of production for each controlling item listed on the schedule during the period such item is controlling.

The Contractor shall confer with the Engineer at regular intervals in regard to the prosecution of the work according to the progress schedule or critical path schedule.

When the contract provides a specified number of working days and at any time the number of working days charged exceeds the proposed working days shown on the approved schedule by ten working days, the Engineer will select the controlling item of work for the purpose of charging working days. When the contract specifies a completion date and at any time the actual progress is 14 calendar days behind the proposed progress shown on the approved schedule, the Engineer will select the controlling item of work for the purpose of checking the progress of the work. The Engineer will continue to determine the controlling item until the Contractor has submitted a satisfactory revised progress schedule or critical path schedule.

No payment under this contract will be made until a progress schedule has been submitted for approval. Payment may be withheld until a satisfactory schedule has been submitted and approved.

108.03 Prosecution of the Work. The Contractor shall begin the work to be performed under the contract not later than ten days after the execution of the contract by the Department, unless otherwise provided in the contract. The work shall be prosecuted in such a manner and with such a supply of materials, equipment and labor as is considered necessary to ensure its completion according to the time specified in the contract.

The Contractor shall notify the Engineer at least 24 hours in advance of either discontinuing or resuming operations.

108.04 Working Days. When the contract provides a specified number of working days, the charging of working days will start when the Contractor begins actual construction work, and in no case later than ten days after the execution and approval of the contract, unless otherwise provided in the contract or directed by the Engineer.

A working day shall be defined as any calendar day between May 1 and November 30 inclusive, except Saturdays, Sundays, or legal holidays observed by the Contractor's entire work force in Illinois. The length of a working day will be determined by the Engineer from the number of working hours established by actual job practice by the Contractor for the current controlling item, except not less than eight hours will be considered in the determination.

A full working day will be charged for any day described in the foregoing on which conditions are such that the Contractor could be expected to do a full day's work on the controlling item. A full working day will be charged on days when the Contractor could be working on a controlling item, but elects not to work, or elects to work elsewhere.

No allowance will be made for delay or suspension of the work due to the fault of the Contractor.

The Engineer will determine which days are workable. One copy of the "Weekly Report of the Resident Engineer" will be mailed to the Contractor's office weekly. Any disagreement with the working day charges shown must be filed in writing with the Engineer within seven calendar days of receipt of the Report giving detailed reasons for the disagreement. The receipt shall be for purposes of the contract, deemed to occur three calendar days after the day of the mailing indicated on the report. The final resolution of such disagreement will be made by the Engineer. By not filing a detailed disagreement within the seven day period, the Contractor will be deemed to have accepted the report as correct and no further challenge will be allowed.

The basis for charging working days shall be as follows.

- (a) A partial working day of one-quarter, one-half, or three-quarters will be charged under the following conditions.

- (1) When weather conditions do not permit the completion of a full day's work on the controlling item.
 - (2) When job conditions due to recent weather do not permit full efficiency of the men or equipment which are working on the controlling item.
 - (3) A shortage of help which is beyond the Contractor's control prevents reasonable progress on a controlling item.
 - (4) When any condition over which the Contractor has no control prevents completing a full day's production on the controlling item.
- (b) No working day will be charged under the following conditions.
- (1) When adverse weather prevents work on the controlling item.
 - (2) When job conditions due to recent weather prevent work on the controlling item.
 - (3) When work has been suspended by an act or an omission of the Department or Engineer.
 - (4) When strikes, lock-outs, extraordinary delays caused by utility and Railroad work, extraordinary delays in transportation, or inability to procure critical materials suspend work on the controlling item, as long as these delays are not due to any fault of the Contractor.
 - (5) When any condition over which the Contractor has no control causes suspension of work on the controlling item.

108.05 Completion Date and Completion Date Plus Working Days.

- (a) Completion Date. When a completion date is specified, the Contractor shall complete all work subject to the date on or before the specified date.
- (b) Completion Date Plus Working Days. When a completion date plus working days is specified, the Contractor shall complete the major items of work as specified in the contract, on or before the completion date. The Contractor shall complete the off-the-road or miscellaneous items of work within the specified number of working days after the completion date.

108.06 Labor, Methods, and Equipment. The Contractor shall, at all times, employ and provide sufficient labor, tools, equipment, and other incidental items for prosecuting the work to full completion in the manner and time required by the contract.

All workers shall have sufficient skills and experience to perform properly the work assigned to them. Workers engaged in special work or skilled work shall have sufficient experience in such work and in the operation of the equipment required to perform all work properly and satisfactorily.

Any person employed by the Contractor or by any subcontractor who, in the opinion of the Engineer, does not perform work in a proper and skillful manner or is intemperate or disorderly shall, at the written request of the Engineer, be removed at once by the Contractor or subcontractor employing such person, and shall not be employed again in any portion of the work without the approval of the Engineer.

Should the Contractor fail to remove such person or persons as required above, or fail to furnish suitable and sufficient personnel for the proper prosecution of the work, the Engineer may suspend the work by written notice until such orders are complied with.

All equipment which is proposed to be used on the work shall be of sufficient size and in such mechanical condition as to meet requirements of the work and to produce a satisfactory quality of work. Equipment used on any portion of the project shall be such that no injury to the roadway, adjacent property, or other highways will result from its use.

When the methods and equipment to be used by the Contractor in accomplishing the construction are not prescribed in the contract, the Contractor is free to use any methods or equipment that can be demonstrated to the Engineer as satisfactory to accomplish the contract work in conformity with the requirements of the contract.

When the contract specifies that the construction be performed by the use of certain methods and equipment, such methods and equipment shall be used unless others are authorized by the Engineer. If the Contractor desires to use a method or type of equipment other than specified in the contract, he/she may request authority from the Engineer to do so. The request shall be in writing and shall include a full description of the methods and equipment proposed to be used and an explanation of the reasons for desiring to make the change. If approval is given, it will be on the condition that the Contractor will be fully responsible for producing construction work in conformity with contract requirements. If, after trial use of the substituted methods or equipment, the Engineer determines that the work produced does not meet contract requirements, the Contractor shall discontinue the use of the substitute method or equipment and shall complete the remaining construction with the specified methods and equipment. The Contractor shall remove the deficient work and replace it with work of specified quality, or take such other corrective action as the Engineer may direct. No change will be made in basis of payment for the construction items involved nor in contract time as a result of authorizing a change in methods or equipment under these Provisions.

108.07 Suspension of Work. The Engineer shall have authority to suspend the work whole or in part, when unsuitable severe weather conditions or other conditions at the site of the work make for circumstances beyond the Contractor's control, which are unfavorable for the satisfactory performance of the work, and when the Contractor does not comply with the contract or orders of the Engineer. Orders to suspend or resume work shall be complied with immediately. If it becomes necessary to stop work for an indefinite period of time, the Contractor shall store all materials in such manner that they will not obstruct or impede the traveling public unnecessarily or become damaged in any way, take every precaution to prevent damage or deterioration of the work performed, provide suitable drainage of the roadway, and erect temporary structures where necessary. The Contractor shall not suspend work without written authority from the Engineer.

The period of suspension shall not count against the time of performance established in the contract unless the suspension is ordered due to the acts or omissions of the Contractor. Extensions of time will be evaluated according to Article 108.08. Except as provided herein below for suspension of an unreasonable duration, the Contractor shall not be paid additional compensation on account of any suspension ordered pursuant to this Article.

If the performance of all or any portion of the work is suspended or delayed by the Engineer in writing for an unreasonable period of time and the Contractor believes that additional compensation and/or contract time is due as a result of such suspension or delay, the Contractor shall submit to the Engineer in writing a request for adjustment within seven calendar days of receipt of the notice to resume work. The request shall set forth the reasons and support for such adjustment.

Upon receipt, the Engineer will evaluate the Contractor's request. If the Engineer agrees that the period of suspension was unreasonable and that the cost and/or time required for the performance of the contract has increased as a result of such suspension, the Engineer will make an adjustment (excluding profit) and modify the contract in writing accordingly. In no case shall a suspension of less than seven calendar days be considered unreasonable. No adjustment will be made for a suspension of any duration, if the suspension was caused by the acts or omissions of the Contractor, subcontractor, suppliers, or the weather. The Engineer will notify the Contractor of his/her determination whether or not an adjustment of the contract is warranted.

No contract adjustment will be allowed unless the Contractor has submitted the request for adjustment within the time prescribed. No contract adjustment will be allowed under this clause to the extent that performance would have been suspended or delayed by any other cause, or for which an adjustment is provided for or excluded under any other term or condition of this contract.

108.08 Determination and Extension of Contract Time. Determination and extension of contract time shall be as follows.

- (a) **Working Days.** When the contract provides a specified number of working days, it is understood that completion of the work within the specified number of working days is an essential part of the contract. The Contractor's plea that insufficient time was specified is not a valid reason for extension of time.

A request for an extension of time may be initiated by either the Engineer or the Contractor. If the Department finds that the quantities of work done, or to be done, are in excess of the estimated quantities by an amount sufficient to warrant additional time, it may grant an extension of time for completion which appears reasonable and proper. The extended number of working days for completion shall then be considered as in effect the same as if it were the original time for completion.

- (b) **Completion Date.** When a completion date is specified, it is understood that time is of the essence and that completion of the work by that date is an

essential part of the contract. The Contractor's plea that insufficient time was specified is not a valid reason for extension of time.

In the event of delay in the work beyond the reasonable control of the Contractor resulting from:

- (1) Conduct or lack of conduct by the Department or its consultants, representatives, officers, agents, or employees; or delay by the Department in making the site available; or in furnishing any items required to be furnished to the Contractor by the Department;
- (2) Extraordinary conditions of weather for the area and time of year with the understanding that the completion time contemplated by this contract anticipates a certain number of lost days due to normal weather conditions, therefore only unusual or extreme weather conditions for the time of year will be considered as justification for a delay in completion of the work;
- (3) War, national conflicts, terrorist acts, or priorities arising therefrom, including restrictions of the ability to procure critical materials;
- (4) Fires;
- (5) Epidemics;
- (6) Strikes or other labor disruptions extending in duration more than five calendar days;
- (7) Utility or railroad adjustments;
- (8) Material delivery delay caused by strikes, lockouts, wrecks, or freight embargoes;
- (9) Subject to compliance with the requirements of Article 105.08, the operations of other contractors working within the limits of the contract or coordinated contracts; or
- (10) Cataclysmic events.

And for no other cause or causes, the Contractor shall be entitled to a reasonable extension of time only by the amount of time the Contractor is actually delayed thereby in the performance of the work, provided notice requesting an adjustment to the completion date is given as herein provided. Contractor shall not be entitled to any extension of time unless the Contractor notifies the Department in writing within 21 calendar days of the commencement of each such delay; requests an adjustment within 21 calendar days of the conclusion of such delay; and failure of the Contractor to request an adjustment in conformity with this Article shall be deemed a waiver of the same. Interim completion dates incorporated into a contract subject to a final completion date, and completion date plus working days contracts shall be governed by these provisions.

The Contractor recognizes it is imperative that the work proceed uninterrupted and shall endeavor to prevent and shall promptly cure any work stoppage caused by any labor or jurisdictional disputes arising out of the assignment of work to be performed by the Contractor or its subcontractors or subcontractors of any tier.

After the Contractor has filed a request for an extension of time, the Department will notify the Contractor, in writing, whether or not such extension will be approved. The Engineer will consider how timely the Contractor prosecuted the work up to the point of the delay according to the progress schedule approved according to Article 108.02 when considering the request. No extension of time will be granted unless the delay in completion of the work was caused specifically by a delay in a portion of the work that was on the critical path of the progress schedule, and that was otherwise on schedule. If approved, the extended date for completion shall then be considered as in effect the same as if it were the original date for completion.

- (c) Regardless of whether the contract is governed by (a) or (b) of this Article, extensions of time granted for reasons or events beyond the reasonable control of the Department shall be the exclusive relief provided, and no additional compensation or claim for damages will be paid or awarded under this or any other provision of the Contract unless the allowance of additional compensation or relief from damages is expressly allowed by a provision of the contract.

108.09 Failure to Complete the Work on Time. Time is of the essence to the contract. Should the Contractor fail to complete the work within the working days stipulated in the contract or on or before the completion date stipulated in the contract or within such extended time as may have been allowed, the Contractor shall be liable and shall pay to the Department the amount shown in the following schedule of deductions, not as a penalty but as liquidated damages, for each day of overrun in the contract time or such extended time as may have been allowed. The liquidated damages for failure to complete the contract on time are approximate, due to the impracticality of calculating and proving actual delay costs. This schedule of deductions establishes the cost of delay to account for administration, engineering, inspection, and supervision during periods of extended and delayed performance. The costs of delay represented by this schedule are understood to be a fair and reasonable estimate of the costs that will be borne by the Department during extended and delayed performance by the Contractor of the work, remaining incidental work, correction of work improperly completed, or repair of work damaged as a result of the Contractor. The liquidated damage amount specified will accrue and be assessed until final completion of the total physical work of the contract even though the work may be substantially complete. The Department will deduct these liquidated damages from any monies due or to become due to the Contractor from the Department.

Schedule of Deductions for Each Day of Overrun in Contract Time			
Original Contract Amount		Daily Charges	
From More Than	To and Including	Calendar Day	Work Day
\$ 0	\$ 100,000	\$ 475	\$ 675
100,000	500,000	750	1,050
500,000	1,000,000	1,025	1,425
1,000,000	3,000,000	1,275	1,725
3,000,000	6,000,000	1,425	2,000
6,000,000	12,000,000	2,300	3,450
12,000,000	And over	5,800	8,125

When a completion date is specified, the daily charge will be made for every day shown on the calendar beyond the specified completion date. When the time limit is specified as working days, the daily charge will be made for each additional working day, computed as specified in Article 108.04.

If contracts are awarded on the basis of a multiple bid, the contract amounts of the individual contracts comprising the multiple bid will be totaled and the daily charge shall be that required for such total amount.

108.10 Default on Contract. If the Contractor fails to begin the work under contract within the time specified, or fails to perform the work with sufficient workers and equipment or with sufficient materials to ensure the completion of said work within the specified time, or shall perform the work unsuitably, as determined by the Engineer, or shall neglect or refuse to remove materials or perform anew such work as shall be rejected as defective and unsuitable, or shall discontinue the prosecution of the work, or if the Contractor shall become insolvent or be declared bankrupt, or shall commit any act of bankruptcy, or insolvency, or shall make an assignment for the benefit of creditors, or from any other cause whatsoever shall not carry on the work in a manner approved by the Engineer or otherwise fails to conform to the terms of the contract, the Engineer will give notice in writing to the Contractor and the Contractor's surety of such delinquency, said notice to specify the corrective measures required. If the Contractor, within a period of ten days after said notice, shall not proceed according to, the Department shall, upon written certificate from the Engineer of the fact of such delinquency and the Contractor's failure to comply with said notice, have full power and authority to forfeit the rights of the Contractor and at its option to call upon the surety to complete the work according to the terms of the contract, or it may take over the work, including any or all materials and equipment on the ground as may be suitable and acceptable, and may complete the work with its own forces, or use such other methods as, in its opinion, shall be required for the completion of said contract in an acceptable manner.

When the Department calls upon the Surety to complete, the Surety shall enter upon the premises and take possession of all materials, tools, and appliances for the purpose of completing the work under the contract and employ by contract or otherwise any person or persons satisfactory to the Department to finish the work

without termination of the contract. Such employment shall not relieve the Surety of its obligations under the contract and the bond. Payments on estimates covering work subsequent to the transfer shall be made to the extent permitted under law to the Surety or its agent without any right of the Contractor to make any claim.

The Contractor shall bear any extra expenses incurred by the State in completing the work, including all increased cost for completing the work, and all damages sustained, or which may be sustained, by the State by reason of such breach refusal, neglect, failure, or discontinuance of work by the Contractor. After all the work contemplated by the contract has been completed, the Engineer will calculate the total expenses and damages for the completed work. If the total expenses and damages are less than any unpaid balance due the Contractor, the excess will be paid by the Department to the Surety or the Contractor. If the total expenses and damages exceed the unpaid balance, the Contractor and the Surety shall be jointly and severally liable to the Department and shall pay the difference to the Department on demand.

If a notice of termination for default has been issued and it is later determined for any reason that the Contractor was not in default, the rights and obligations of the parties shall be the same as if the notice of termination had been issued pursuant to Termination for Public Convenience in Article 108.12.

108.11 Termination of the Contractor's Responsibility. Whenever the improvements called for by the contract has been completely performed on the part of the Contractor and all parts of the work have been approved by the Engineer and accepted by the Department according to the contract, and the final estimate paid, the Contractor's obligations shall then be considered fulfilled, except those obligations which by their nature extend beyond the completion of work including but not limited to Articles 107.26, 107.27, 107.33, and 107.34.

108.12 Termination for Public Convenience. The Department may, by written order, terminate the contract or any portion thereof after determining that for reasons beyond either Department or Contractor control, the Contractor is prevented from proceeding with or completing the work as originally contracted for, and that termination would, therefore, be in the public interest. Such reasons for termination may include, but need not be necessarily limited to, Executive Orders of the President relating to prosecution of war or national defense, national emergency which creates a serious shortage of materials, orders from duly constituted authorities relating to energy conservation, and restraining orders or injunctions obtained by third-party citizen action resulting from national or local environmental protection laws or where the issuance of such order or injunction is primarily caused by acts or omissions of persons or agencies other than the Contractor.

When contracts, or any portion thereof, are definitely terminated or cancelled, and the Contractor released before all items of work included in his/her contract have been completed, payment will be made for the actual number of units of items of work completed at contract unit prices, or as specified in Article 109.06 for partially completed items, and no claims for loss of anticipated profits will be considered. Reimbursement for organization of the work and moving equipment to and from the job will be considered where the volume of the work completed is too small to compensate the Contractor for these expenses under the contract unit prices, the intent being that an equitable settlement will be made with the Contractor.

Acceptable materials, obtained by the Contractor for the work, that have been inspected, tested and accepted by the Engineer, and that are not incorporated in the work may, at the option of the Engineer, be purchased from the Contractor at actual costs as shown by receipted bills and actual cost records at such points of delivery as may be designated by the Engineer.

Termination of a contract, as stated above, will not relieve the Contractor or his/her surety of the responsibility of replacing defective work as required by the contract.

SECTION 109. MEASUREMENT AND PAYMENT

109.01 Measurement of Quantities. Completed work, which is to be measured for payment, will be measured by the Engineer according to the United States standard measures. The units of measure shall be English (metric) and shall correspond to the units in the contract. Metric units are generally "hard" converted and Appendix B of this book lists conversion factors for the exact English equivalents.

All measurements for length will be made linearly unless otherwise specified. Longitudinal measurements for areas of base courses, surface courses, pavement, and shoulders will be made along the actual surface of the roadway. For transverse measurements for areas of base courses, surface courses, pavements, and shoulders, the dimensions used in calculating the pay areas shall be the exact horizontal dimensions shown on the plans or the dimensions ordered in writing by the Engineer. No deduction will be made for fixtures in the roadway having an area of 9 sq ft (0.84 sq m) or less.

All measurements for weight shall be from scales meeting the requirements of The Weights and Measures Act of the State of Illinois. The Contractor shall provide accurate weights of materials delivered to the contract for incorporation into the work, whether temporary or permanent, for which the basis of payment is by weight. These weights shall be documented on delivery tickets which shall identify the source of the material, type of material, the date and time the material was loaded, the contract number, the net weight, the tare weight when applicable, and the identification of the transporting vehicle.

The Department will conduct random, independent vehicle weight checks for material sources.

Should the vehicle weight check for a source result in the net weight of material on the vehicle exceeding the net weight of material shown on the delivery ticket by 0.50 percent (0.70 percent for aggregates) or more, the Engineer will document the independent vehicle weight check and immediately furnish a copy of the results to the Contractor. No adjustment in pay quantity will be made.

Should the vehicle weight check for a source result in the net weight of material shown on the delivery ticket exceeding the net weight of material on the vehicle by 0.50 percent (0.70 percent for aggregates) or more, the Engineer will document the independent vehicle weight check and immediately furnish a copy of the results to the Contractor. The Engineer will adjust the net weight shown on the delivery ticket to the

checked delivered net weight as determined by the independent vehicle weight check.

The Engineer will also adjust the method of measurement for subsequent deliveries from the source based on the independent weight check. The net weight of all materials delivered to all contracts from this source, for which the basis of payment is by weight, will be adjusted by applying a correction factor "A" as determined by the following formula:

$$A = 1.0 - \left(\frac{B - C}{B} \right); \text{ Where } A \leq 1.0 \text{ and } \left(\frac{B - C}{C} \right) > 0.50\% \text{ (0.70\% for aggregates)}$$

Where A = Adjustment factor

B = Net weight shown on delivery ticket

C = Net weight determined from independent weight check

The adjustment factor will be applied as follows:

Adjusted Net Weight = A x Delivery Ticket Net Weight

The adjustment factor will be imposed until the cause of the deficient weight is identified and corrected by the Contractor to the satisfaction of the Engineer. If the cause of the deficient weight is not identified and corrected within seven calendar days, the source shall cease delivery of all materials for which the basis of payment is by weight.

Should the Contractor elect to challenge the results of the independent weight check, the Engineer will continue to document the weight of material for which the adjustment factor would be applied. However, provided the Contractor furnishes the Engineer with written documentation that the source scale has been calibrated within seven calendar days after the date of the independent weight check, adjustments in the weight of material paid for will not be applied unless the scale calibration demonstrates that the source scale was not within the specified Department of Agriculture tolerance.

At the Contractor's option, the vehicle may be weighed on a second independent Department of Agriculture certified scale to verify the accuracy of the scale used for the independent weight check.

109.02 Scope of Payment. The Contractor shall receive and accept the compensation as herein provided, in full payment for furnishing all materials, labor, tools, and equipment; for performing all work contemplated and embraced under the contract; for all loss or damage arising out of the nature of the work and from the action of the elements; for any unforeseen difficulties or obstructions which may arise or be encountered during the prosecution of the work until its final acceptance by the Department; for all risks of every description connected with the prosecution of the work; for all expenses incurred by or in consequence of suspension or discontinuance of such prosecution of the work as herein specified; for any infringement of patents, trademarks or copyrights; and for completing the work in an acceptable manner according to the plans and Specifications.

The payment of any current estimate prior to final acceptance of the work by the Department shall in no way constitute an acknowledgement of the acceptance of the work, nor in any way prejudice or affect the obligation of the Contractor, at his/her own expense, to repair, correct, renew, or replace any defects or imperfections in the construction or in the strength or quality of the materials used in or about the construction of the work under contract and its appurtenances, nor any damage due or attributable to such defects, which defects, imperfections or damage shall have been discovered on or before the final inspection and acceptance of the work. The Engineer shall be the sole judge of such defects, imperfections or damage, and the Contractor shall be liable to the Department for failure to correct the same as provided herein.

109.03 Increased or Decreased Quantities. Whenever the quantity of any pay item as given in the proposal shall be increased or decreased, payment shall be made on the basis of the actual quantity completed at the unit price for such pay item named in the proposal, except as otherwise provided in Article 104.02, or in the detailed Specifications for each class of work. Should any pay items contained in the proposal be found unnecessary for the proper completion of the work, the Engineer may, upon written order to the Contractor, eliminate such pay items from the contract, and such action shall in no way invalidate the contract. When a Contractor is notified of the elimination of pay items, the Contractor will be reimbursed for actual work done and all costs incurred, including mobilization of materials prior to said notification.

109.04 Payment for Extra Work. Extra work which results from any of the changes as specified in Article 104.02 shall not be started until authorization from the Engineer is received, which authorization shall state the items of work to be performed and the method of payment for each item. Work performed without such order will not be paid for.

Extra work will be paid for at either the contract price, a lump sum price or agreed unit prices, or on a force account basis.

- (a) **Lump Sum Price or Agreed Unit Prices.** When extra work is to be paid for at either a lump sum price or agreed unit prices, the lump sum or unit prices shall be agreed upon by the Contractor and the Engineer.
- (b) **Force Account Basis.** When extra work is to be paid for by force account, the basis for the force account shall be as follows.
 - (1) **Labor.** For all labor and foremen in direct charge of the specific operations, the Contractor shall receive the actual normal rate of wage paid for each and every hour that said labor and foremen are actually engaged in such work.

The Contractor shall receive the actual costs paid to, or in behalf of, workers by reason of subsistence and travel allowances, health and welfare benefits, pension fund benefits or other benefits, when such amounts are required by collective bargaining agreement or other employment contract generally applicable to the classes of labor employed on the work.

An amount equal to 35 percent of the sum of the above items will also be paid the Contractor.

- (2) Bond, Insurance, and Tax. For property damage, liability, and workmen's compensation insurance premiums, unemployment insurance contributions, and social security taxes on the force account work, the Contractor shall receive the actual cost, to which ten percent will be added. The Contractor shall furnish satisfactory evidence of the rate or rates paid for such bond, insurance, and tax.
- (3) Materials. For materials accepted by the Engineer and used, the Contractor shall receive the actual cost of such materials delivered on the work, including transportation charges paid by the Contractor (exclusive of machinery rentals as hereinafter set forth), to which cost 15 percent will be added.
- (4) Equipment. Equipment used for extra work shall be authorized by the Engineer. The equipment shall be specifically described, be of suitable size and capacity for the work to be performed, and be in good operating condition. For such equipment, the Contractor will be paid as follows.
 - a. Contractor Owned Equipment. Contractor owned equipment will be paid for by the hour using the applicable FHWA hourly rate from the "Equipment Watch Rental Rate Blue Book" (Blue Book) in effect when the force account work begins. The FHWA hourly rate is calculated as follows.

FHWA hourly rate = (monthly rate/176) x (model year adj.) x (Illinois adj.) + EOC

Where: EOC = Estimated Operating Costs per hour (from the Blue Book)

The time allowed will be the actual time the equipment is operating on the extra work. For the time required to move the equipment to and from the site of the extra work and any authorized idle (standby) time, payment will be made at the following hourly rate: $0.5 \times (\text{FHWA hourly rate} - \text{EOC})$.

All time allowed shall fall within the working hours authorized for the extra work.

The rates above include the cost of fuel, oil, lubrication, supplies, small tools, necessary attachments, repairs, overhaul and maintenance of any kind, depreciation, storage, overhead, profits, insurance, and all incidentals. The rates do not include labor.

The Contractor shall submit to the Engineer sufficient information for each piece of equipment and its attachments to enable the Engineer to determine the proper equipment category. If a rate is not established in the Blue Book for a particular piece of

equipment, the Engineer will establish a rate for that piece of equipment that is consistent with its cost and use in the industry.

- b. Rented Equipment. Whenever it is necessary for the Contractor to rent equipment to perform extra work, the rental and transportation costs of the equipment plus five percent for overhead will be paid. In no case shall the rental rates exceed those of established distributors or equipment rental agencies.

All prices shall be agreed to in writing before the equipment is used.

- (5) Miscellaneous. No additional allowance will be made for general superintendence, the use of small tools, or other costs for which no specific allowance is herein provided.
- (6) Statements. No payment will be made for work performed on a force account basis until the Contractor has furnished the Engineer with itemized statements of the cost of such force account work. Statements shall be accompanied and supported by invoices for all materials used and transportation charges. However, if materials used on the force account work are not specifically purchased for such work but are taken from the Contractor's stock, then in lieu of the invoices, the Contractor shall furnish an affidavit certifying that such materials were taken from his/her stock, that the quantity claimed was actually used, and that the price and transportation claimed represent the actual cost to the Contractor.

Itemized statements at the cost of force account work shall be detailed as follows.

- a. Name, classification, date, daily hours, total hours, rate, and extension for each laborer and foreman. Payrolls shall be submitted to substantiate actual wages paid if so requested by the Engineer.
 - b. Designation, dates, daily hours, total hours, rental rate, and extension for each unit of machinery and equipment.
 - c. Quantities of materials, prices and extensions.
 - d. Transportation of materials.
 - e. Cost of property damage, liability and workmen's compensation insurance premiums, unemployment insurance contributions, and social security tax.
- (7) Work Performed by an Approved Subcontractor. When extra work is performed by an approved subcontractor, the Contractor shall receive, as administrative costs, an amount equal to five percent of the total approved costs of such work with the minimum payment being \$100.

- (8) All statements of the cost of force account work shall be furnished to the Engineer not later than 60 days after receipt of the Central Bureau of Construction form "Extra Work Daily Report". If the statement is not received within the specified time frame, all demands for payment for the extra work are waived and the Department is released from any and all such demands. It is the responsibility of the Contractor to ensure that all statements are received within the specified time regardless of the manner or method of delivery.

109.05 Expenses Incurred by the Department. Upon written request of the Engineer, the Contractor shall pay the bills which are the responsibility of the Department. The Contractor shall receive as administrative costs an amount equal to five percent of the first \$10,000 and one percent of any amount over \$10,000 of the total actual amount paid per bill with the minimum payment being \$100.

109.06 Payment for Items Omitted When Partially Completed. Should the Department cancel or alter any portion of the contract which results in the elimination or noncompletion of any portions of the work partially completed, the Contractor will be allowed a fair and equitable amount covering all items of work incurred prior to the date of cancellation, alteration, or suspension of such work.

The Contractor shall be allowed a profit percentage on the materials used and the construction work actually performed at the rate specified in Article 109.04, but no allowance will be made for any change in anticipated profits. Acceptable materials ordered by the Contractor or delivered on the work prior to the date of its cancellation, alteration or suspension by the Engineer will be purchased from the Contractor by the Department at actual cost and shall thereupon become the property of the Department; or at the option of the Engineer, the unused acceptable material shall remain the property of the Contractor, and the Contractor will be paid the actual cost including freight, unloading, and hauling costs less the actual salvage value.

109.07 Partial Payments. Partial payments will be made as follows.

- (a) **Progress Payments.** At least once each month, the Engineer will make a written estimate of the quantity of work performed in accordance with the contract, and the value thereof at the contract unit prices. The amount of the estimate approved as due for payment will be vouchered by the Department and presented to the State Comptroller for payment. No amount less than \$1000.00 will be approved for payment other than the final payment.

The failure to perform any requirement, obligation, or term of the contract by the Contractor shall be reason for withholding any progress payments until the Department determines that compliance has been achieved. Furthermore, progress payments may be reduced by liens filed pursuant to Section 23(c) of the Mechanics Lien Act, 770 ILCS 60/23(c).

- (b) **Material Allowances.** At the discretion of the Department, payment may be made for materials, prior to their use in the work, when satisfactory evidence is presented by the Contractor. Satisfactory evidence includes justification for the allowance (to expedite the work, meet project schedules, regional or national material shortages, etc.), documentation of material and transportation costs, and evidence that such material is properly stored on

the project or at a secure location acceptable and accessible to the Department.

Material allowances will be considered only for nonperishable materials when the cost, including transportation, exceeds \$10,000 and such materials are not expected to be utilized within 60 days of the request for the allowance. For contracts valued under \$500,000, the minimum \$10,000 requirement may be met by combining the principal (material) product of no more than two contract items. An exception to this two item limitation may be considered for any contract regardless of value for items in which material (products) are similar, except for type and/or size.

Material allowances shall not exceed the value of the contract items in which used and shall not include the cost of installation or related markups. Amounts paid by the Department for material allowances will be deducted from estimates due the Contractor as the material is used. Proof of payment for materials and transportation shall be furnished to the Department within 60 days of payment of the allowances or the amounts will be reclaimed by the Department.

109.08 Acceptance and Final Payment. Whenever the improvement provided for by the contract has been completely performed on the part of the Contractor, and all parts of the work have been approved by the Engineer, a final estimate showing the value of the work will be prepared by the Engineer as soon as the necessary measurements and computations can be made, all prior estimates upon which payments have been made being approximate only and subject to correction in the final payment.

Final acceptance occurs by signature on the final estimate and the date of this signature constitutes the acceptance date. Final acceptance shall not constitute acceptance of any unauthorized or defective work or material. The Department shall not be barred from requiring the removal, replacement, repair, or disposal of any unauthorized or defective work or material or from recovering damages from any such work or material.

As soon as possible after final inspection, the final quantities will be sent to the Contractor by certified mail. The Contractor shall respond within 21 days of receipt by either signing and thus accepting the final quantities or by disagreeing in writing, citing the pay items involved with documentation and justification of such disagreement. Failure to respond within the 21 days will be considered as acceptance of final quantities and the Department will proceed with final payment.

The amount of this estimate, less any sums that have been deducted or retained under the Provisions of the contract, will be paid to the Contractor as soon as practicable after the final approval of the work, provided there exists no liens filed against the public funds according to the law.

When the State of Illinois is the awarding authority, unless the Contractor files a claim for adjudication by the Court of Claims according to Article 109.09, the final payment shall constitute a release and waiver of any and all rights and privileges under the terms of the contract, and shall relieve the Department from any and all

claims or liabilities for anything done or furnished relative to the work or for any act or neglect on the part of the Department relating to or connected with the contract.

When the county or municipality is the awarding authority, the final payment shall constitute a release and waiver of any and all rights and privileges under the terms of the contract, and shall relieve the Department from any and all claims or liabilities for anything done or furnished relative to the work or for any act or neglect on the part of the Department relating to or connected with the contract.

109.09 Contract Claims. If the Contractor claims that additional payment is due under the terms of the contract or for any other reason arising out of the performance of the contract and the Department has not agreed, during the ordinary course of contract administration, that payment is due, the Contractor desiring to pursue additional compensation shall file a claim according to the requirements and procedures specified herein. If written notifications are not given, or if the Department is not afforded reasonable access by the Contractor to complete records of actual costs or additional time, or if a claim is not filed according to the procedures and within the time specified herein, then the claim is waived and the Department is released from any and all demands and claims. The fact that the Contractor has provided a proper notification, provided a properly filed claim, or provided the Department access to records of actual cost, shall not in any way be construed as proving or substantiating the validity of the claim. If the claim, after consideration by the Department, is found to have merit, the Department will make an equitable adjustment either in the amount of costs to be paid according to the Basis of Payment specified herein or in the time required for the work or both. If the Department finds the claim to be without merit, no adjustment will be made.

The Contractor may present a claim made by a subcontractor founded upon the terms of the contract or the actions and orders of the Engineer without being first required to make payment to the subcontractor provided: the Contractor makes written certification that the subcontractor is entitled to additional compensation; that the subcontractor will be paid in the event of a favorable resolution of the claim; and that the subcontract, releases, and waivers executed by the subcontractor do not bar payment to the subcontractor. The written certification may authorize the subcontractor to present the subcontractor claim directly to the Department. If such authorization is given, the Contractor need not participate in the verbal presentation of the claim. In any event, the submission shall include a copy of the subcontract, and any releases or waivers signed by the subcontractor in favor of the Contractor. The Contractor's interest in the subcontractor's claim shall not be assigned or otherwise disposed of, except as specified in Article 108.01.

- (a) **Submission of Claim.** All claims filed by the Contractor shall be in writing and in sufficient detail to enable the Department to ascertain the basis and amount of the claim. All claims shall be submitted to the Regional Engineer. As a minimum, the following information must accompany each claim submitted.
 - (1) A detailed factual statement of the claim for additional compensation and time, if any, providing all necessary dates, locations, and items of work affected by the claim.

- Under penalty of law for perjury or falsification, the undersigned,

hereby certifies that the claim for compensation and time, if any, made herein for work on this contract is a true statement, fully documented and supported under the contract between the parties.

Dated _____ /S/ _____

Subscribed and sworn before me this _____ day
of _____

Notary Public

My Commission Expires

- (b) Record Retention. It is the responsibility of the Contractor to keep full and complete records of the costs and additional time incurred for any claim. The Contractor shall permit the Department to have access to those records and any other records as may be required by the Department to determine the facts or contentions involved in the claim. The Contractor shall retain those records according to Article 109.10.
- (c) Audit. All claims filed against the State shall be subject to audit at any time following the filing of the claim. The audit may be performed by employees of the State or by an auditor under contract with the State. The audit may begin at any time during the life of the contract, or on 20 calendar days notice to the Contractor or its agents if an audit is to be commenced more than 60 calendar days after the final payment date of the contract. The Contractor, subcontractors, or agents shall provide adequate facilities acceptable to the Department, for the audit during normal business hours. Failure of the Contractor or its agents to maintain and retain sufficient records to allow the auditors to verify all or any portion of the claim or to permit the auditor access to the books and records of the Contractor, subcontractors, or agents shall constitute a waiver of the claim and may bar any recovery of all or any portion thereunder.

The records subject to retention and audit are all books and records including but not limited to the following documents.

- (1) Daily time sheets and supervisor's daily reports.
- (2) Union agreements.
- (3) Payroll records including tax, insurance, welfare, and benefits records.
- (4) Material invoices and requisitions.
- (5) Material cost distribution worksheet.
- (6) Equipment records (list of company equipment, rates, etc.).
- (7) Vendor's, rental agencies subcontractor's, and agent's invoices.
- (8) Subcontractor's and agent's payment certificates.
- (9) Cancelled checks (payroll and vendors).
- (10) Job cost report.
- (11) Job payroll ledger.
- (12) General ledger.
- (13) Cash disbursements journal.
- (14) Financial statements for all years reflecting the operations on the contract involved.

- (15) Depreciation records on all company equipment.
 - (16) If a source other than depreciation records is used to develop costs for the Contractor's internal purposes in establishing the actual costs of owning and operating equipment, all such other source documents.
 - (17) All documents including pricing books and bid documents which relate to each and every claim together with all documents which support the amount of damages as to each claim.
 - (18) Worksheets used to prepare the claim establishing the cost components for items of the claim including but not limited to labor, benefits and insurance, materials equipment, subcontractors all documents which establish the time periods individuals involved, the hours for the individuals and the rates of the individuals.
- (d) Time of Submission. Notice of the intent to file a claim shall be given to the Department within 21 days of receipt of the final quantities. All claims submitted according to this Article shall be filed not later than six months after the Department provides final quantities to the Contractor according to Article 109.08. The six months shall run from the date indicated on the final quantities transmittal. The requirement of a general administrative claims cutoff time provided herein shall not constitute a waiver of any notification time requirements stated elsewhere in these specifications or the special provisions.
- (e) Procedure. The Department provides three administrative levels for claims review.
- | | |
|-----------|--|
| Level I | Regional Engineer |
| Level II | Central Bureau of Construction |
| Level III | Chief Engineer/Director of Highways or
Assistant Chief Engineer/Deputy Director of Highways |

All claims shall first be submitted at Level I. This Regional Engineer will consider all information submitted with the claim and render a decision on the claim within 90 days after receipt. Claims not conforming to this Article will be returned without consideration. The Regional Engineer may schedule a claim presentation meeting if in the Regional Engineer's judgment such a meeting would aid in resolution of the claim, otherwise a decision will be made based on the claim documentation submitted. If a decision is not rendered within 90 days, or if the Contractor disputes the decision, an appeal to Level II shall be made by the Contractor. An appeal to Level II shall be made in writing to the Regional Engineer within 45 days after the date of the Level I decision, and shall include two additional copies of the claim and supporting documentation. Review of the claim at Level II shall be conducted as a full evaluation of the claim. A claim presentation meeting may be scheduled if the Bureau Chief of Construction determines that such a meeting would aid in resolution of the claim, otherwise a decision will be made based on the claim documentation submitted. If a Level II decision is not rendered within 90 days after receipt of the written appeal, or

if the Contractor disputes the decision, an appeal at Level III shall be made in writing to the Central Bureau of Construction within 45 days of the date of the Level II decision. Review of the claim at Level III shall be conducted as a full evaluation of the claim. A claim presentation meeting may be scheduled if the Chief Engineer/Director of Highways determines that such a meeting would aid in resolution of the claim, otherwise a decision will be made based on the claim documentation submitted. A Level III final decision will be rendered within 90 days of the receipt of the written request for appeal.

Full compliance by the Contractor with the provisions specified in this Article is a contractual condition precedent to the Contractor's right to seek relief in the Court of Claims. The Director's written decision shall be the final administrative action of the Department. Unless the Contractor files a claim for adjudication by the Court of Claims within 60 days after the date of the written decision, the failure to file shall constitute a release and waiver of the claim.

- (f) **Basis of Payment.** After resolution of a claim in favor of the Contractor, any adjustment in time required for the work will be made according to Section 108. Any adjustment in the costs to be paid will be made for direct labor, direct materials direct equipment, direct jobsite overhead, direct offsite overhead, and other direct costs allowed by the resolution. Adjustments in costs will not be made for interest charges, loss of anticipated profit, undocumented loss of efficiency, prorata home office overhead, unabsorbed overhead and lost opportunity, preparation of claim expenses and other consequential indirect costs regardless of method of calculation.

The above Basis of Payment is an essential element of the contract and the claim cost recovery of the Contractor shall be so limited.

109.10 Contractor Record Retention. All books and records required to be maintained by the Contractor and subcontractor shall be maintained as provided for elsewhere in the contract. The Contractor and subcontractor shall cooperate fully with any audit and provide full access to all relevant materials. Failure by the Contractor or subcontractor to maintain the books, records and supporting documents required by this Article shall establish a presumption in favor of the State for the recovery of any funds paid by the State under the contract for which adequate books and records are not available. The Contractor and subcontractor shall include the requirements of this Article in all subcontracts.

DIVISION 200. EARTHWORK, LANDSCAPING, AND EROSION CONTROL**EARTHWORK****SECTION 201. CLEARING, TREE REMOVAL AND PROTECTION, CARE AND REPAIR OF EXISTING PLANT MATERIAL**

201.01 Description. This work shall consist of performing the following items wherever they occur within the right-of-way, or within the limits of construction, including the areas of borrow pits furnished by the Department.

- (a) **Clearing.** Clearing shall consist of the removal and disposal of all obstructions such as fences, walls, foundations, buildings, accumulations of rubbish of whatever nature and existing structures, the removal of which is not otherwise provided for in Article 501.07; all logs, shrubs, bushes, saplings, grass, weeds, other vegetation and stumps of a diameter less than 6 in. (150 mm).
- (b) **Tree Removal.** Tree Removal shall consist of the cutting, grubbing, removal, and disposal of trees and stumps, as hereinafter defined.
- (c) **Protection of Existing Plant Material.** Protection of existing plant material shall consist of directing work activity away from and protecting trees, shrubs, turf, and herbaceous plants on and adjacent to the right-of-way.
- (d) **Care of Existing Plant Material.** Care of existing plant material shall consist of pruning, fertilizing, and watering existing plant material to maintain health and vigor during and following construction activity.
- (e) **Repair or Replacement of Existing Plant Material.** Repair or replacement of existing plant material damaged by the Contractor shall consist of restoring to original condition specific plant material that was designated to be saved within the limits of construction, or restoring plant material outside the limits of construction that was damaged by the Contractor.

201.02 Definitions. Tree - A woody, perennial plant having a single main stem or trunk, the diameter of which is 6 in. (150 mm) or more at a point 4.5 ft (1.3 m) above the highest ground level at the base of the tree. Those having a diameter less than 6 in. (150 mm) will be considered saplings. A multiple-stem tree that forks below the 4.5 ft (1.3 m) point of measurement will be considered a cluster of individual trees. A tree that forks at or above the 4.5 ft (1.3 m) point of measurement will be considered a single tree.

A tree stump with a diameter at cut off of 6 in. (150 mm) or more will be considered as a tree for purposes of measurement and removal.

Limits of Construction - A boundary line, not necessarily the right-of-way line, extending along each side of the centerline of the improvement as shown on the plans or cross sections, or as designated by the Engineer.

Root Zone - An area around a plant extending at least as far from the base as the longest horizontal branches.

CONSTRUCTION REQUIREMENTS

201.03 Removal of Obstructions and Other Materials. All items defined as clearing in Article 201.01(a) shall be removed and disposed of as required by these Specifications.

201.04 Tree Removal. Prior to beginning tree removal, all requirements of Article 201.05(a) shall be completed. All trees, except those designated to be saved, and all stumps, shall be cut and disposed of according to Article 202.03. Trees and stumps within the slope limits of embankments 2 ft (600 mm) or more in depth shall be cut off at ground level. All other trees and stumps within the right-of-way shall be removed to a depth of not less than 12 in. (300 mm) below the elevation of the subgrade, the finished earth surface, or the ground line. Trees of Osage Orange shall not be cut off as specified above, but shall be pulled or grubbed in such a manner as to insure complete removal.

201.05 Protection of Existing Plant Material. All plant material designated to be saved, or outside of the limits of construction, shall be protected prior to beginning any clearing or removal work and shall remain protected during subsequent construction work.

Parking or maneuvering of machinery, stockpiling of materials, or any other use will not be allowed upon unpaved areas within 10 ft (3 m) of the root zone of trees or plants designated to be protected.

If requested by the Contractor, the Engineer will stake or otherwise mark these protection limits.

- (a) Temporary Fencing. The Contractor shall manually erect a temporary fence as designated on the plans or where directed by the Engineer. The temporary fence shall be similar to plastic or wood lathe snow fence, and shall be a minimum of 4 ft (1.2 m) high with stakes placed a maximum of 15 ft (4.5 m) apart.
- (b) Tree Trunk Protection. The Contractor shall provide 2 in. x 8 in. x 8 ft (50 mm x 200 mm x 2.4 m) boards banded continuously around each trunk to prevent scarring of trees shown on the plans or designated by the Engineer. For multistem trees, saplings, and shrubs to be protected within the area of construction, temporary fencing may be used for trunk protection.
- (c) Pruning for Safety and Equipment Clearance. All pruning shall be done according to the current ANSI A300 (Part 1) – Pruning standard. Plant material shall be pruned to provide a minimum vertical clearance of 20 ft (6 m) from the finished surface of the road bed and shoulders. Pruning for sight distance and other safety purposes shall be as shown on the plans or as directed by the Engineer. Branches on existing plant material to remain that need to be removed for safety or equipment clearance shall be pruned prior to or during the clearing operation. Breaking off branches of plant

material to remain during clearing or construction operations will not be allowed.

201.06 Care of Existing Plant Material. Root and tree pruning shall be performed as follows.

- (a) **Root Pruning.** If construction is to occur within the root zone of existing plant material, root pruning and special plant care will be required. All pruning shall be performed by a professional arborist.

Root pruning using an approved mechanical root pruning saw shall be performed prior to digging where noted on the plans, or directed by the Engineer. Whenever roots of plant material to remain are exposed during construction, the damaged root ends are to be removed by cutting them off cleanly.

Pruning shall be done in the presence of the Engineer and in such a manner as to preserve the natural growth habit of each plant.

Any damage to the root zone, as determined by the Engineer, shall be compensated by pruning an equivalent amount of the top vegetative growth of the plant material within one week following root damage.

The procedure of "drop crotch" pruning shall be employed for all trimming of branches in excess of 2 in. (50 mm) in diameter.

Fertilizing and watering after root pruning shall be as follows.

- (1) **Fertilizer Nutrients.** Fertilizer nutrients shall be applied within 48 hours after root damage occurs. A fertilizer with a 1:1:1 ratio shall be applied at the rate of 5 lb (2 kg) of nutrients per 1000 sq ft (90 sq m).

Application shall be accomplished by placing dry fertilizer in holes in the soil. The holes shall be 8 to 12 in. (200 to 300 mm) deep and spaced 2 ft (600 mm) apart in an area beginning 30 in. (750 mm) from the base of the plant. Holes shall be punched with a punch bar, dug with a spade, drilled with an auger, or any other method approved by the Engineer. Approximately 0.02 lb (10 g) of fertilizer nutrients shall be placed in each hole [250 holes/1000 sq ft (250 holes/90 sq m)].

If the Engineer determines that the hole method of fertilizer placement is not practical or desirable, an approved method of uniform surface application will be allowed.

- (2) **Supplemental Watering.** In case of inadequate rainfall, as determined by the Engineer, supplemental water shall be applied within 48 hours of any root damage. The water shall be applied at the rate of 2 gal/sq yd (9 L/sq m) of surface area within the root zone of plant material having sustained damage to the root zone. Subsequent weekly waterings shall be applied if deemed necessary by the Engineer.

- (b) **Tree Pruning.** Tree pruning shall consist of pruning branches, for aesthetic and structural enhancement, of existing trees as shown on the plans or as directed by the Engineer. All pruning shall be done according to the current ANSI A300 (Part 1) – Pruning standard. All branch pruning shall be done between October 15 and April 15, when the trees are dormant.

201.07 Repair or Replacement of Existing Plant Material. The Contractor shall repair or replace any and all damage, deemed unnecessary by the Engineer to any existing or newly installed plant material. Unnecessary damage to ground cover or turf shall be repaired or replaced as specified for restoration of similar areas within the plans, or as directed by the Engineer.

All replacement planting under this Article shall be according to Section 253 and Article 1081.01; and shall be barerooted, or balled and burlapped according to the transplanting requirements of the plants.

Replacement, if required, shall be as follows.

- (a) **Trees.** Furnish, deliver, and plant a tree of the same species and variety and of the same size; or furnish, deliver, and plant at locations designated by the Engineer, a number of saplings of the same species and variety, each having a minimum diameter of 2 in. (50 mm), with the sum of the inch (millimeter) - diameters of saplings equaling the inch (millimeter) diameter of the tree to be replaced.
- (b) **Shrubs, Small Trees or Evergreens.** Furnish, deliver, and plant a plant of the same species and variety, and of the same size in height or width; or furnish, deliver and plant at locations designated by the Engineer, a number of plants of the same species and variety whose total measurements shall equal the measurement of the plant to be replaced, measured as above.

201.08 Removal of Saplings, Bushes and Roots. Prior to beginning removal of saplings, bushes, and roots, all requirements of Article 201.05(a) shall be completed. All saplings and bushes, except those designated to be saved, and all roots within the slope limits of embankments 2 ft (600 mm) or more in depth shall be cut off at the ground level. All other saplings, bushes and roots within the right-of-way shall be removed to a depth of not less than 12 in. (300 mm) below the elevation of the subgrade, the finished earth surface, or the ground line, and at least below the bottom of the subbase material. Bushes of Osage Orange shall not be cut off as specified above, but shall be pulled or grubbed in such a manner as to insure complete removal.

201.09 Disposal of Materials. Materials shall be disposed of according to Article 202.03.

201.10 Method of Measurement. This work will be measured for payment as follows.

- (a) **Clearing.** Clearing will not be measured for payment.
- (b) **Tree Removal.**

- (1) Unit Diameter. Trees to be removed as a payment item, but not measured in acres (hectares), will be measured per unit of diameter where one unit is equal to 1 in. (25 mm). The diameter will be measured at a point 4.5 ft (1.3 m) above the highest ground level at the base of the tree and will be determined by dividing the measured circumference of the tree by 3.1416. Stumps will be measured at the elevation of cut off. A multiple stem tree's branches having a diameter of 6 in. (150 mm) or more at a point 4.5 ft (1.3 m) above the highest ground level at the base of the tree will be measured for payment as individual trees. The accumulated total number of units will be the pay quantity.
 - (2) Acre (Hectare) as Unit.
 - a. Contract Quantities. The requirements for the use of contract quantities shall be according to Article 202.07.
 - b. Measured Quantities. Trees to be removed will be measured by the acre (hectare) when included in the contract as a payment item and shown at definite locations on the plans or staked for removal by the Engineer. The entire area shown on the plans, and directed by the Engineer, will be used in computing the acres (hectares). No deductions will be made for bare areas and existing roads occurring within these limits. Any removal of bushes or saplings within such areas will not be measured separately for payment.
 - (3) When it is necessary to remove trees in connection with borrow pits furnished by the Contractor, trees will not be measured for payment.
- (c) Protection of Existing Plant Material.
- (1) Temporary Fencing. Temporary fencing will be measured for payment in feet (meters) in place.
 - (2) Tree Trunk Protection. Tree trunk protection will be measured for payment as each per tree. A tree with from one to three stems with one stem having a diameter of 6 in. (150 mm) or more or a sapling shall be measured as one tree. Tree trunk protection shall include furnishing, installing and removing this item.
 - (3) Pruning for Safety and Equipment Clearance. Pruning for safety and equipment clearance will not be measured for payment.
- (d) Care of Existing Plant Material.
- (1) Tree Root Pruning. Tree root pruning will be measured for payment as each per tree. Roots pruned on trees with one to three stems with one stem having a diameter equal to or greater than 6 in. (150 mm) will be measured as individual items. All pruning, including top pruning necessary to maintain the vigor of the tree, shall be completed prior to measurement for payment.

Trimming of roots exposed during excavation will not be measured for payment.

- (2) Fertilizer Nutrients. Fertilizer will be measured by weight (mass) in pounds (kilograms) of actual nutrients used.
- (3) Supplemental Watering. Supplemental watering will be measured for payment in units of 1000 gal (1000 L) of water applied to the root zones of plant material.
- (4) Tree Pruning. Tree pruning for trees and saplings 1 to 10 in. (25 to 250 mm) in diameter will be measured for payment as each per tree or sapling. Tree pruning for trees over 10 in. (250 mm) in diameter will be measured for payment as each per tree. Measurement of trunk diameters will be according to Article 201.10(b)(1).

201.11 Basis of Payment. This work will be paid for as follows.

- (a) Tree Removal. Tree removal will be paid for at the contract unit price per unit diameter for TREE REMOVAL (6 to 15 UNITS DIAMETER) or TREE REMOVAL (OVER 15 UNITS DIAMETER); and per acre (hectare) for TREE REMOVAL, ACRES (HECTARES).

If the contract includes a payment item for Tree Removal, Acres (Hectares) but does not include a payment item for Tree Removal, Units Diameter, any tree removal not paid for as Tree Removal, Acres (Hectares), will be paid for according to Article 109.04.

- (b) Protection of Existing Plant Material. This work will be paid for at the contract unit price per foot (meter) for TEMPORARY FENCE and at the contract unit price per each for TREE TRUNK PROTECTION.

If no pay items have been established in the contract for the protection of existing plant material, this work will be paid for according to Article 109.04.

- (c) Care of Existing Plant Material. This work will be paid for at the contract unit price per each for TREE ROOT PRUNING, TREE PRUNING (1 TO 10 IN. DIAMETER) (25 TO 250 MILLIMETERS DIAMETER), or TREE PRUNING (OVER 10 IN. DIAMETER) (OVER 250 MILLIMETERS DIAMETER); at the contract unit price per pound (kilogram) for NITROGEN FERTILIZER NUTRIENT, POTASSIUM FERTILIZER NUTRIENT, or PHOSPHORUS FERTILIZER NUTRIENT; and at the contract unit price per unit for SUPPLEMENTAL WATERING.

Top pruning necessary to maintain the vigor of the tree will not be paid for as a separate item, but shall be included in the bid price for TREE ROOT PRUNING.

If no pay items have been established in the contract for the care of existing plant material, this work will be paid for according to Article 109.04.

SECTION 202. EARTH AND ROCK EXCAVATION

202.01 Description. This work shall consist of the excavation and transportation of suitable excavated material to embankment locations throughout the limits of the contract, or the excavation, transportation, and disposal of excavated material. This work does not include excavation for structures or channel excavation.

CONSTRUCTION REQUIREMENTS

202.02 Clearing, Tree Removal, and Protection of Existing Plant Material. Prior to starting excavation operations in any area, all clearing, tree removal, and protection of existing plant material in that area shall be performed according to Section 201.

202.03 Removal and Disposal of Surplus, Unstable, and Unsuitable Materials and Organic Waste. Suitable excavated materials shall not be wasted without permission of the Engineer. The Contractor shall dispose of all surplus, unstable, and unsuitable materials and organic waste, in such a manner that public or private property will not be damaged or endangered.

Suitable earth, stones and boulders naturally occurring within the right-of-way may be placed in fills or embankments in lifts and compacted according to Section 205. Broken concrete without protruding metal bars, bricks, rock stone, reclaimed asphalt pavement with no expansive aggregate, or uncontaminated dirt and sand generated from construction or demolition activities may be used in embankment or in fill. If used in fills or embankments, these materials shall be placed and compacted to the satisfaction of the Engineer; shall be buried under a minimum of 2 ft (600 mm) of earth cover (except when the materials include only uncontaminated dirt); and shall not create an unsightly appearance or detract from the natural topographic features of an area. Broken concrete without protruding metal bars, bricks, rock, or stone may be used as riprap as approved by the Engineer. If the materials are used for fill in locations within the right-of-way but outside project construction limits, the Contractor must specify to the Engineer, in writing, how the landscape restoration of the fill areas will be accomplished. Placement of fill in such areas shall not commence until the Contractor's landscape restoration plan is approved by the Engineer.

Aside from the materials listed above, all other construction and demolition debris or waste shall be disposed of in a licensed landfill, recycled, reused, or otherwise disposed of as allowed by State or Federal solid waste disposal laws and regulations and solid waste determinations of the IEPA.

A permit shall be obtained from IEPA and made available to the Engineer prior to open burning of organic waste (i.e., plant refuse resulting from pruning or removal of trees or shrubs) or other construction or demolition debris. Organic waste originating within the right-of-way limits may be chipped or shredded and placed as mulch around landscape plantings within the right-of-way when approved by the Engineer. Chipped or shredded material to be placed as mulch shall not exceed a depth of 6 in. (150 mm).

When the Contractor proposes to dispose of surplus excavated material off the right-of-way, the Contractor shall obtain and file with the Engineer permission in writing, from the property owner, for the use of the property for this purpose. The approval of the proposed disposal site shall be according to Article 107.22. Any such disposal shall not create an unsightly or objectionable appearance or detract from the natural topographic features, nor be placed at an elevation higher than that of the adjacent roadway without permission from the Engineer.

All unstable and unsuitable material, including excavated material from sewer trenches or other underground construction, shall be excavated or removed and replaced with material as shown on the plans. Unstable and unsuitable material shall not be used in embankments. If unsuitable material is present at or below the finished grade, it shall be removed and replaced with subbase granular material, Type A or Type B, according to Section 311. Unsuitable material shall be placed as directed by the Engineer within the right-of-way or disposed of by the Contractor outside of the right-of-way.

202.04 Classification. Excavation material will be classified by the Engineer. All excavation will be classified as earth excavation, except those materials provided for in rock excavation, excavation for structures, channel excavation, and rock excavation in channel.

Rock excavation shall consist of the excavation from the roadway of boulders 1/2 cu yd (0.5 cu m) in volume or greater and all rock in ledges, bedded deposits and conglomerate deposits exhibiting the physical characteristics and difficulty of rock removal as determined by the Engineer.

Rock shall be excavated to a minimum 3 in. (75 mm) below the subgrade of the proposed pavement, surface course, or base course, and backfilled with subbase granular material, Type A or Type B to the elevations shown on the plans. The surface of the rock excavation shall be free from projecting points, ribs, crevices or undrained pockets. The method of rock removal shall be the option of the Contractor. However, excessive blasting or overshooting will not be permitted.

202.05 Drainage. The excavation shall be maintained so that positive drainage is provided at all times. Ditches and waterways shall be constructed and maintained to the lines, grades, and cross sections shown on the plans. The Contractor shall also excavate a ditch at the toe of slope for fills and at the top of slope for cuts at locations designated by the Engineer at the earliest opportunity during construction to control runoff from the embankment or cut section. Material excavated from ditches at the top of slope of cuts shall be placed in a windrow between the ditch and top of slope.

If during the prosecution of the work, it is necessary to interrupt existing sewer or under drainage to complete contract requirements, temporary drainage facilities shall be provided until the permanent drainage work has been completed. The Contractor shall preserve and protect all existing sewer and drainage facilities within the limits of the contract. The Contractor shall be responsible for all cost associated with the repair of sewer or drainage facilities damaged due to negligence on the Contractor's part.

202.06 Excavation for Base Course Widening and Hot-Mix Asphalt Shoulders for Pavement Resurfacing. Excavation for the construction of base course widening and for hot-mix asphalt (HMA) shoulders when the existing pavement is not to be widened shall be performed according to the details shown on the plans or as directed by the Engineer. The excavated material shall be used to backfill the remaining portion of the widening trench after the widening has been constructed and to grade and reshape the shoulders to the new gradeline shown on the plans after the pavement resurfacing has been completed. Backfill shall be completed within 24 hours. The excavated material shall be deposited on the shoulders in such a manner that it will not interfere with drainage or the construction of the base course widening or shoulders and the pavement resurfacing until it can be bladed into final position.

Any surplus excavation not needed for the shoulder reshaping or any unsuitable material shall be disposed of according to Article 202.03.

If sufficient material is not obtained from the excavation for the widening or HMA shoulder to complete the shoulder grading, the additional material shall be obtained as follows.

- (a) From Within the Right-of-Way. The additional material shall be obtained from ditches within the right-of-way as directed by the Engineer. The foreslopes, backslopes and ditches in areas from which the additional material is obtained shall be shaped and finished as directed by the Engineer. The longitudinal haul shall not exceed 3 miles (5 km). If material obtained from the ditches is wet and/or difficult to handle, the Contractor may be required to disk and harrow the shoulder after placement of the material.
- (b) From an Outside Source. If additional material is not available within the existing right-of-way, the Contractor, when authorized by the Engineer, may secure material from a source of his/her own choosing provided the material conforms to the requirements of Article 204.02.

202.07 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. When the project is constructed essentially to the lines, grades, or dimensions shown on the plans, and the Contractor and the Engineer have agreed in writing that the plan quantities are accurate, no further measurement will be required and payment will be made for the quantities shown in the contract for the various items involved, except that if errors are discovered after work has been started, appropriate adjustments will be made.

When the plans have been altered or when disagreement exists between the Contractor and the Engineer as to the accuracy of the plan quantities, either party shall, before any work is started which would affect the measurement, have the right to request in writing and thereby cause the quantities involved to be measured.

- (b) Measured Quantities. Earth and rock excavation will be measured in their original positions, and the volumes in cubic yards (cubic meters) computed by the method of average end areas. The volume of any unstable or unsuitable material removed will be measured for payment in cubic yards (cubic meters).

In rock excavation, the Contractor shall strip ledge rock of overburden so that necessary cross sections for measurement may be taken. Vertical measurements for determining end areas shall extend from the surface of the rock to an elevation not more than 6 in. (150 mm) below the subgrade of the proposed pavement structure, as shown on the plans, or to the bottom of the rock where that point is above the subgrade of the proposed pavement structure. Horizontal measurements for determining end areas shall extend not more than 6 in. (150 mm) beyond the slope lines fixed by the Engineer for the work. Boulders and rocks 1/2 cu yd (0.5 cu m) or more in volume will be measured individually and the volume computed from average dimensions taken in three directions.

Subbase granular material used for replacement will be measured in tons (metric tons) or in cubic yards (cubic meters) according to Article 311.08.

Subbase granular material used for replacement of rock excavation more than 6 in. (150 mm) below the subgrade of the proposed pavement structure will not be measured for payment.

Earth moved more than once due to either stage construction or by written authorization of the Engineer will be measured for payment each time it is moved.

Earthwork required for the construction of base course widening for pavement resurfacing will be measured for payment to the neat lines as shown on the plans and the volume computed in cubic yards (cubic meters).

Earthwork required for the construction of HMA shoulders for pavement resurfacing will be measured for payment in units of 100 ft (30 m) along each edge of the pavement.

Additional material needed to reshape the shoulders that is obtained from within the right-of-way will be measured for payment as specified above for earth excavation.

202.08 Basis of Payment. Earth and rock excavation will be paid for at the contract unit prices per cubic yard (cubic meter) for EARTH EXCAVATION and ROCK EXCAVATION, respectively, which prices shall include other items of work included under the general heading of Earthwork for which no payment item is included in the contract.

Removal and disposal of unstable and/or unsuitable material will be paid for at the contract unit price per cubic yard (cubic meter) for REMOVAL AND DISPOSAL OF UNSUITABLE MATERIAL.

Subbase granular material will be paid for according to Article 311.09.

When the contract does not contain a pay item for removal and disposal of unstable and/or unsuitable material and this item is required, it will be paid for according to Article 109.04.

When the contract does not contain pay items for rock excavation or subbase granular material, and these items are required, they will be paid for according to Article 109.04.

Earthwork required for the construction of base course widening for pavement resurfacing will be paid for at the contract unit price per cubic yard (cubic meter) for EARTH EXCAVATION (WIDENING).

Earthwork required for the construction of HMA shoulders for pavement resurfacing will be paid for at the contract unit price per unit for EXCAVATING AND GRADING EXISTING SHOULDER.

Additional material required in reshaping the shoulders to the new grade line for pavement resurfacing that is obtained from within the right-of-way will not be paid for separately, but shall be included in the contract unit price per cubic yard (cubic meter) for EARTH EXCAVATION. Additional material required in reshaping the shoulders to the new grade line for pavement resurfacing that is obtained from an outside source will be paid for according to Article 109.04.

Temporary drainage facilities required during the course of construction will be paid for according to Article 109.04 unless otherwise provided for in the contract.

SECTION 203. CHANNEL EXCAVATION

203.01 Description. Channel excavation shall consist of the removal and satisfactory disposal of all materials encountered in the construction of new stream channels and in widening, deepening, or straightening existing stream channels.

CONSTRUCTION REQUIREMENTS

203.02 Classification. Excavation in channel will be classified as channel excavation and rock excavation in channel, according to Article 202.04.

203.03 Clearing, Tree Removal, and Protection of Existing Plant Material. Prior to starting excavation operations, all clearing, tree removal, and protection of existing plant material shall be performed according to Section 201.

203.04 Excavation. The Contractor shall notify the Engineer, at least three days in advance of starting excavation operations, to permit the completion of accurate measurements for volume determinations. Any material excavated before such measurements have been taken will not be paid for.

Channels shall be excavated according to the lines, grades, and cross sections shown on the plans; there shall be no deviation from the dimensions shown without

the written consent of the Engineer. Excavated materials shall be disposed of as shown on the plans or as directed by the Engineer.

Where piles are to be driven as a part of the permanent improvement, any channel excavation at the location of such piles shall be completed to the final elevation before the piles are driven.

203.05 Method of Measurement. Channel excavation and rock excavation in channel will be measured for payment according to Article 202.07.

203.06 Basis of Payment. Channel excavation will be paid for at the contract unit prices per cubic yard (cubic meter) for CHANNEL EXCAVATION and ROCK EXCAVATION IN CHANNEL.

When the contract does not contain a unit price for rock excavation in channel, and such excavation is required, it will be paid for according to Article 109.04.

SECTION 204. BORROW AND FURNISHED EXCAVATION

204.01 Description. Borrow excavation and furnished excavation shall consist of excavating suitable materials obtained from locations approved by the Engineer and transporting the materials to various locations throughout the limits of the contract.

204.02 Borrow Pits. The Contractor shall furnish and pay for all borrow sites or other sources of borrow and obtain from the property owners the necessary agreements for the removal of the material. Neither borrow nor furnished excavation shall be placed in the embankment until the site location, excavation plan, and material have been approved by the Engineer in writing. The material used shall have a Standard Dry Density of not less than 90 lb/cu ft (1450 kg/cu m) when tested according to AASHTO T 99 (Method C) and shall not possess an organic content greater than ten percent when tested according to AASHTO T 194.

At the Contractor's option, commercial borrow sites may be used. When commercial borrow sites are used, the following conditions will not be required.

Under no condition shall borrow sites detract from the appearance of the natural topographic features nor increase the potential hazard to a vehicle that has inadvertently left the roadway. In selecting sites for borrow acquisition, preference shall be given to knobs, hills and rises to reduce the extent of pit development. No portion of any borrow pit shall be located within 50 ft (15 m) or 10 ft (3 m) plus 1 1/2 times the depth of the excavation, whichever is the greater, from any highway right-of-way, except when borrow is obtained above pavement elevation. In order to ensure an aesthetically acceptable borrow site, the steepest slopes used in excavating borrow shall be 1:4 (V:H).

Borrow pits shall not change the general pattern of existing drainage and shall be well drained unless suitable for development as ponds or lakes. Pertinent drainage information shall be shown on the excavation plan or topographic map submitted by the Contractor.

Where the Contractor proposes a borrow site, any portion of which is located within 150 ft (45 m) of any highway right-of-way, the Contractor's request for approval shall be accompanied by a topographic map showing the original and the proposed final conditions of the entire borrow site. The topographic map shall be drawn to a minimum horizontal scale of 1:500, and 2 ft (600 mm) contour intervals shall be indicated.

When a borrow pit is to be developed as a pond or lake, the Contractor shall submit to the Engineer a written statement from the owner that such a development is planned. Slopes of 1:4 (V:H) shall be provided along the periphery of the shoreline. Slopes of 1:2 (V:H) will be permitted below a point where the proposed water depth will be 8 ft (2.5 m) or greater. In cases where a dam is necessary to impound water within a borrow pit to be used as a pond, slopes of 1:3 (V:H) will be permitted on the water face of the dam. Seeding will not be required below the proposed water elevation.

Borrow sites shall be seeded according to Section 250. The class of seeding and the application rate of fertilizer nutrients and/or ground limestone will be determined by the Engineer. If the proposed borrow site is to revert to agricultural purposes, the Contractor shall submit to the Engineer a written statement from the owner that seeding will not be required. All work in connection with seeding at borrow sites will not be paid for separately.

After the borrow site excavation is completed, the Contractor shall shape the borrow site to conform to the approved topographic map.

204.03 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Steel Based Plate	1006.04
(b) Steel Pipe	1006.18
(c) Threaded Malleable Iron Floor Flanges	1006.16

All materials furnished to construct settlement platforms will be visually inspected by the Engineer at the job site prior to installation and no other inspection or certification will be required.

CONSTRUCTION REQUIREMENTS

204.04 Clearing, Tree Removal, and Protection of Existing Plant Material.

Before any material is excavated from a borrow pit, clearing, tree removal and protection of existing plant material over the area included within the limits of the pit shall be performed according to Section 201.

204.05 Excavation.

Excavation throughout the borrow pit area shall be as uniform as possible. Upon completion of the excavation operations, all stumps and roots shall be cut off and disposed of according to Article 202.03, and the pits shall be trimmed and cleaned.

204.06 Settlement Platforms.

When called for on the plans or should the Contractor request credit for the placement of any additional embankment due to

possible settlement during construction, settlement platforms shall be erected at the locations shown on the plans or as directed by the Engineer and as hereinafter specified. Notification by the Contractor shall be made to the Engineer in writing prior to the start of construction.

The settlement platforms shall be placed on natural soil, where practical, after the roadway area has been cleared, disked and compacted. Compacted granular bedding material up to 6 in. (150 mm) thick may be used to properly seat the platform. Granular material to be used for bedding may consist of any fine aggregate meeting the approval to the Engineer. The subgrade or bedding shall be prepared and leveled in such a manner that the platform makes uniform contact.

A 3/4 in. (19 mm) diameter steel pipe shall be attached to a 1/8 in. (3 mm) thick by 4 ft (1.2 m) square steel plate with a threaded malleable iron floor flange welded to the plate. 4 ft (1.2 m) lengths of 3/4 in. (19 mm) diameter pipe shall be added as the height of the embankment increases. The tip of the grade pipe shall at no time extend more than 4 1/2 ft (1.4 m) or less than 6 in. (150 mm).

The Contractor shall exercise extreme caution when placing material adjacent to the settlement plates and no equipment shall pass within 5 ft (1.5 m) of the settlement plate until the height of fill is 3 ft (1 m) above the plate.

A casing of 2 1/2 in. (64 mm) diameter steel pipe (standard) shall be installed around the vertical pipe.

Settlement platforms shall be maintained by the Contractor in the required positions at all times during the construction of the embankment. All movement or disturbance, other than normal settlement, of the settlement platforms shall be immediately corrected by the Contractor by repairing or replacing them as directed by the Engineer. All extensions to the grade pipes shall be added under the supervision of the Engineer.

Settlement readings will be taken by the Engineer as required prior to and after construction of the embankment. The final readings will be taken after the top grade of the embankment has been constructed and has been approved by the Engineer.

When the settlement platform has served its purpose, the pipe extensions shall be removed to at least 2 ft (600 mm) below subgrade, the pipe capped, and the area backfilled and compacted.

204.07 Method of Measurement. Borrow excavation will be measured in its original position by taking cross sections before the work is started and again after it has been completed. The volume, in cubic yards (cubic meters), of material moved will be computed by the method of average end areas.

Furnished excavation will be measured for payment as follows.

(a) Contract Quantities. The use of contract quantities shall conform to the requirements of Article 202.07(a) and to the following.

(1) If the Contractor so requests, the Engineer will reestablish the existing ground line after the clearing and tree removal over the entire

embankment areas have been performed according to Section 201 and the top 6 in. (150 mm) of the existing ground surface has been disked and compacted to the satisfaction of the Engineer. Contract quantities will be recalculated based on the difference between the existing ground line shown on the plans and the new ground line established after the clearing, disked and compacting.

- (2) If the settlement platforms are erected, the Engineer will reestablish the Existing ground line after the embankment is complete from elevations taken on the grade pipes of the settlement platforms. In reestablishing the existing ground line, no change in elevation from that shown on the plan cross sections will be assumed to have occurred at the intersection of the embankment side slopes and the existing ground. Contract quantities will be recalculated based on the difference between the existing ground line shown on the plans and the new ground line established from the settlement platforms.
- (b) Measured Quantities. Furnished excavation will be computed for payment in cubic yards (cubic meters) as follows.

$$\text{Furnished Ex.} = \text{Embankment} - [\text{Suitable Ex.} \times (1 - \text{Shrinkage Factor})]$$

Where:

Embankment = the volume of fill in its final position computed by the method of average end areas and based upon the existing ground line as shown on the plans, except as noted in (1) and (2) below;

Suitable Excavation = earth excavation, rock excavation, and other on-site excavation suitable for use in embankments as shown in the Earthwork Schedule on the plans;

Shrinkage Factor = 0.25 unless otherwise shown on the plans.

- (1) If the Contractor so requests, the Engineer will reestablish the existing ground line after the clearing and tree removal have been performed according to Section 201 and the top 6 in. (150 mm) of the existing ground surface has been disked and compacted.
- (2) If settlement platforms are erected, the Engineer will reestablish the existing ground line after the embankment is complete as specified in Article 204.07(a)(2).

The quantity for furnished excavation will not be recalculated when surplus, suitable materials are utilized in embankments according to Article 202.03.

204.08 Basis of Payment. Borrow and furnished excavation will be paid for at the contract unit prices per cubic yard (cubic meter) for BORROW EXCAVATION and FURNISHED EXCAVATION.

SECTION 205. EMBANKMENT

205.01 Description. This work shall consist of the construction of embankments by depositing, placing, and compacting earth, stone, gravel, or other materials of acceptable quality above the natural ground or other surface.

205.02 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Disk Harrow	1101.02

CONSTRUCTION REQUIREMENTS

205.03 Preparation of Existing Ground Surface. Before any embankment is placed, all clearing and tree removal over the entire roadway area shall be performed according to Section 201, and the top 6 in. (150 mm) of the existing ground surface shall be disked and then compacted. Snow and ice shall be removed from the area to be covered by the embankment. Embankment shall not be placed on frozen earth. When construction is resumed after any winter shutdown period, the top 8 in. (200 mm) of all partially completed embankments shall be reprocessed and compacted to the minimum specified density prior to placing more fill material on the embankment.

When embankments are to be constructed on hillsides or slopes, or if existing embankments are to be widened or included in new embankments, the existing slopes shall be plowed deeply. If additional precautions for binding the fill materials together are justified, steps shall be cut into the existing slopes before the construction of the embankment is started.

When embankments are to be constructed over an existing pavement, the following shall govern.

- (a) Aggregate Surfaces and Bituminous Surface Treatments over Aggregate Bases. When the surface of the pavement is within 6 in. (150 mm) of the elevation of the subgrade, it shall be plowed, disked, or otherwise broken up to a depth of not less than 6 in. (150 mm).
- (b) Hot-Mix Asphalt Base Courses, Surfaces, and Pavements; and Portland Cement Concrete Base Courses and Pavements.
 - (1) When the distance between the existing pavement and the proposed subgrade is between 3 in. (75 mm) and 3 ft (1 m), the existing pavement shall be broken into pieces not to exceed 3 sq ft (0.3 sq m) in surface area. At the option of the Contractor, the broken roadway may stay in place unless otherwise directed by the Engineer.
 - (2) When the distance between the existing pavement and the proposed subgrade is less than 3 in. (75 mm), the existing pavement shall be removed.

205.04 Placing Material. Embankments shall be constructed of materials that will compact and develop stability. No sod, frozen material, or any material which, by decay or otherwise, might cause settlement shall be placed or allowed to remain in embankments within the area of the roadbed. Embankments shall be constructed to the height and width deemed necessary to provide for shrinkage during compaction. Upon completion, the embankments shall be according to the lines, grades, and cross sections shown on the plans. When embankments are constructed of materials specified in Article 202.03, such materials shall be well distributed, and sufficient earth, or other fine material shall be incorporated with them when they are deposited to fill the interstices and provide solid embankment. No rock, stones or broken concrete more than 4 in. (100 mm) in largest dimension shall be permitted within a vertical distance of 12 in. (300 mm) from the surface of the finished earth grade, or finished earth shoulders. When the contract includes pavement, surface course or base course, the vertical distance may be 3 in. (75 mm) from the finished surface of the subgrade for such construction.

Pieces of concrete, not exceeding 2 sq ft (0.2 sq m) for any area of surface, and large rocks and boulders may be placed in fills without being broken up, provided they are well embedded, and the interstices filled with smaller pieces or smaller material in a manner to give a density satisfactory to the Engineer. The lifts of the smaller pieces or smaller material shall not exceed 12 in. (300 mm) in depth.

So far as practicable, each lift of material shall extend the entire length and width of the embankment. The material shall be leveled by means of bulldozers, blade graders or other equipment approved by the Engineer. Each lift shall be not more than 8 in. (200 mm) thick when in loose condition, uniform in cross section, and thoroughly compacted before the next lift is started.

The use of drag line excavators or similar equipment which excavate and deposit material in large unit masses will not be permitted, unless all materials excavated in this manner are spread as provided herein and compacted according to Article 205.06, or as directed by the Engineer.

205.05 Placing Material Adjacent to Structures. When bridges and culverts are not completed in advance of grading operations, an omission in the embankment of not less than 100 ft (30 m) on each side of each structure shall be made, until such omitted embankment shall be placed later according to the requirements of these Specifications. As an alternate method, an omission in the embankment of sufficient length to permit the completion of the structure and the necessary backfills may be made, provided all backfills and omitted embankments are constructed with granular material furnished and placed at no additional cost to the Department. The granular material shall be according to Article 1004.05, and shall be compacted according to Article 205.06.

Embankment behind abutments or around structures shall not be constructed until test specimens show that the concrete has attained a modulus of rupture of 650 psi (4500 kPa), and at least seven days have elapsed after the completion of the abutment or structure affected. In the absence of tests to determine the modulus of rupture, the minimum length of time between the completion of the abutment or structure and the placing of the embankment shall be at least 14 days exclusive of days in which the temperature falls below 45 °F (7 °C).

Embankment, behind abutments held at the top by the superstructure, shall not be placed until the superstructure has been completed and the false work removed. Embankment, behind such abutments and behind the walls of culverts having a clear height of more than 5 ft (1.5 m), shall be carried up simultaneously at both ends of the structure, and at no time shall the embankment at one end be more than 2 ft (600 mm) higher than at the other.

Backfill shall not be placed in water at closed abutments, culverts or retaining walls. The excavated area around these structures shall be pumped dry, and any mud or loose material within the excavated space shall be removed. Sloping sides of the excavated space shall be removed. Sloping sides of the excavated space, that would be liable to cause objectionable wedging action of the backfill against the structure, shall be stepped or serrated to prevent such action. At piers, backfill may be placed in water, provided that both the water level and backfill are kept at approximately the same elevation on opposite sides of the pier. A time interval, approved by the Engineer, shall elapse before placing additional fill on one side of the pier above the water surface.

A cubical deposit of porous coarse aggregate, at least 2 ft (600 mm) in each dimension, shall be placed in back of each drain hole in abutment and wing walls and culvert side walls. The bottom of this deposit shall be 2 in. (50 mm) below the drain hole. All form boards or other obstructions shall be removed from the drains before the embankment is constructed.

205.06 Compaction. Each lift of the embankment material shall be disked sufficiently to break down oversized clods, mix the different materials, secure a uniform moisture content, and ensure uniform density and compaction. Disking may be omitted if the fill material consists of sand or gravel.

If the roadway embankment is less than 1 1/2 ft (450 mm), all lifts shall be compacted to not less than 95 percent of the standard laboratory density. If the embankment height is between 1 1/2 ft and 3 ft (450 mm and 900 mm) inclusive, the first lift shall be compacted to not less than 90 percent, and the balance to a minimum of 95 percent of the standard laboratory density. If the embankment exceeds 3 ft (900 mm) in height, the lower 1/3 of the embankment, but not to exceed the lower 2 ft (600 mm), shall be compacted in a manner that will yield a minimum of 90 percent of standard laboratory density to the uppermost lift of that portion of the embankment. The next 1 ft (300 mm) of embankment shall be compacted to not less than 93 percent, and the balance of the embankment compacted to not less than 95 percent of the standard laboratory density.

The top 2 ft (600 mm) of all embankments shall not contain more than 120 percent of the optimum moisture determined according to AASHTO T 99 (Method C). The Contractor will be permitted the use of an approved additive to effect a quicker drying time.

The standard laboratory density shall be the maximum dry density determined according to AASHTO T 99 (Method C). A coarse particle correction according to AASHTO T 224 shall be used.

The dry density of the compacted embankment will be determined by the Engineer at regular intervals according to AASHTO T 191, Illinois Modified

AASHTO T 310 (Direct Transmission Density/Backscatter Moisture), or by other methods approved by the Engineer.

The embankment shall be sprinkled with water when it is necessary to increase the moisture content of the soil to permit the embankment to be constructed to the densities indicated above.

Compacting equipment and compacting operations shall be coordinated with the rate of placing embankment so that the required density is obtained.

Special care shall be exercised in compacting embankments adjacent to structures and in sharp depressions. Where such areas are inaccessible to the compacting equipment being used, the material shall be placed in 8 in. (200 mm) horizontal lifts and uniformly compacted with suitable mechanical equipment. Embankment placed adjacent to a structure shall not contain more than 110 percent of the optimum moisture determined according to AASHTO T 99 (Method C).

205.07 Maintaining and Trimming Embankments. The Contractor shall replace any portions of the embankment which have been damaged or displaced by reason of carelessness or negligence on the Contractor's part. After the embankments have been constructed, their sides shall be trimmed to the proper slopes where required, and shall be maintained by the Contractor to the proper elevation and cross section until acceptance.

205.08 Method of Measurement. Embankment will not be measured for payment. Mechanical compaction will not be measured for payment.

205.09 Basis of Payment. Embankment and any additive or water applied will not be paid for directly but shall be considered as included in the various items of excavation, and their construction shall be included in the unit prices for these items.

SECTION 206. GRANULAR EMBANKMENT, SPECIAL

206.01 Description. This work shall consist of the construction of granular embankment by placing and compacting gravel or crushed stone on an existing pavement or surface course.

206.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate (Note 1)	1004.04

Note 1. The aggregate shall have a bearing ratio of not less than 80. For crushed gravel, crushed stone, and crushed slag, the bearing ratio requirement shall not apply. The bearing ratio will be determined according to the Standard Methods adopted by the Department.

206.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Tamping Roller	1101.01
(b) Pneumatic-Tired Roller	1101.01
(c) Three-Wheel Roller (Note 1)	1101.01
(d) Tandem Roller (Note 1)	1101.01
(e) Vibratory Machine (Note 2)	

Note 1. The three-wheel or tandem roller shall weigh from 6 to 10 ton (5.5 to 9 metric ton) and shall weigh not less than 200 lb/in. (35 N/mm) nor more than 325 lb/in. (57 N/mm) of width of the roller.

Note 2. The vibratory machine shall meet the approval of the Engineer.

CONSTRUCTION REQUIREMENTS

206.04 Placing and Compacting Aggregate. The Contractor shall submit to the Engineer a sample of the aggregate to be used for granular embankment at least 15 days prior to starting construction. The sample so submitted will be tested by the Department for acceptance.

The aggregate shall be placed and compacted according to Article 351.05(a) and (b), except that construction shall be alternated on each lane width so that at no time will there be a difference of more than 4 in. (100 mm) in elevation. Construction operations shall be carried on in such a manner that the elevation of adjacent traffic lanes shall be the same when work is suspended at nights and over weekends or holidays.

206.05 Construction of Earth Berm. Prior to allowing traffic on the newly constructed lift, the adjacent earth berm shall be built flush with the top of the aggregate and the edges of the aggregate base compacted to the required density. The cost of constructing the earth berm in this manner will be considered as included in the contract unit price bid for earth excavation, borrow excavation, or furnished excavation.

206.06 Surface Treatment. Immediately following the final shaping and compacting operation, calcium chloride shall be applied to the surface at the rate of 2 to 4 lb/sq yd (1 to 2 kg/sq m) according to Section 663. After the top lift has been completed, it shall be opened to two-way traffic and shall be maintained by the Contractor for traffic until the entire contract is completed and accepted. In no case shall the maintenance period be less than ten days.

206.07 Method of Measurement. This work will be measured for payment in tons (metric tons) or cubic yards (cubic meters) according to Article 311.08.

Aggregate required for maintenance will be measured for payment in tons (metric tons) or cubic yards (cubic meters) according to Article 311.08.

Calcium chloride will be measured for payment according to Article 663.04.

206.08 Basis of Payment. This work will be paid for at the contract unit price per ton (metric ton), or cubic yard (cubic meter) for GRANULAR EMBANKMENT, SPECIAL.

Aggregate required for maintenance will be paid for at the contract unit price per ton (metric ton) or cubic yard (cubic meter) for GRANULAR EMBANKMENT, SPECIAL.

Calcium chloride will be paid for according to Article 663.05.

SECTION 207. POROUS GRANULAR EMBANKMENT

207.01 Description. This work shall consist of furnishing, transporting, and placing porous granular material. For the purpose of this specification, the embankment may be above the original ground line, or it may be below the water elevation.

207.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate	1004.05
(b) Fine Aggregate	1003.04

CONSTRUCTION REQUIREMENTS

207.03 General. The aggregate shall be placed in 6 in. (150 mm) lifts, loose measurement, and compacted in a manner approved by the Engineer, except that if the desired results are being obtained, the compacted thickness of any lift may be increased to a maximum of 8 in. (200 mm).

207.04 Method of Measurement. This work will be measured for payment in tons (metric tons) according to Article 311.08(b), or in cubic yards (cubic meters) compacted in place and the volume computed by the method of average end areas.

207.05 Basis of Payment. This work will be paid for at the contract unit price per ton (metric ton) for POROUS GRANULAR EMBANKMENT, or at the contract unit price per cubic yard (cubic meter) for POROUS GRANULAR EMBANKMENT.

SECTION 208. TRENCH BACKFILL

208.01 Description. This work shall consist of furnishing aggregate for backfilling all trenches made in the subgrade of the proposed improvement, and all trenches where the inner edge of the trench is within 2 ft (600 mm) of the proposed edge of pavement, curb, gutter, curb and gutter, stabilized shoulder, or sidewalk.

This work also includes the disposal of the surplus excavated material which is replaced by trench backfill. Such disposal shall be made according to Article 202.03.

208.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Fine Aggregate (Note 1)	1003.04
(b) Coarse Aggregate (Note 2)	1004.05

Note 1. The fine aggregate shall be moist.

Note 2. The coarse aggregate shall be wet.

208.03 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Trench backfill shall be furnished for backfilling to the full width of the trench. It will be measured in cubic yards (cubic meters) in place, except that the quantity for which payment will be made shall not exceed the volume of the trench as computed by using the maximum width of trench permitted by the Specifications and the actual depth of the completed trench backfill above the center of the pipe, with a deduction for the volume of one-half of the pipe.

Any material conforming to the requirements of Articles 1003.04 or 1004.05 which has been excavated from the trenches shall be used for backfilling the trenches. No compensation will be allowed as trench backfill for the portion of the trench backfilled with excavated material.

208.04 Basis of Payment. This work will be paid for at the contract unit price per cubic yard (cubic meter) for TRENCH BACKFILL.

SECTION 209. POROUS GRANULAR BACKFILL

209.01 Description. This work shall consist of furnishing and placing porous granular material for backfilling tile or pipe in trenches.

209.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate	1004.05
(b) Fine Aggregate	1003.04

CONSTRUCTION REQUIREMENTS

209.03 General. The porous granular material shall be placed around the tile or pipe for the full width of the trench. This material shall be carried to the top of all water bearing strata intercepted by the trench or to a minimum of 1 ft (300 mm) above the tile or pipe, as directed by the Engineer. The material shall be placed in lifts not

exceeding 6 in. (150 mm) in thickness and compacted in a manner approved by the Engineer. The balance of the trench shall be backfilled with approved natural soil.

Surplus excavated material shall be disposed of according to Article 202.03.

209.04 Method of Measurement. Porous granular backfill will be measured for payment in cubic yards (cubic meters) in place, except that the quantity for which payment will be made shall not exceed the volume of the trench as computed by using the maximum width of trench permitted by the Specifications and the actual depth of the completed porous granular backfill above the invert of the pipe, with a deduction for the volume of the pipe. Any porous granular backfill used for the purpose of filling the trench in excess of the maximum quantity specified shall be furnished and placed by the Contractor at his/her own expense.

209.05 Basis of Payment. This work will be paid for at the contract unit price per cubic yard (cubic meter) for POROUS GRANULAR BACKFILL.

SECTION 210. FABRIC FOR GROUND STABILIZATION

210.01 Description. This work shall consist of furnishing and installing geotechnical fabric in subgrades or as embankment foundations.

210.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Geotextile Fabric	1080.02
(b) Coarse Aggregate (Note 1)	1004.04

Note 1. The coarse aggregate shall be that specified for granular embankment special.

CONSTRUCTION REQUIREMENTS

210.03 Installation Requirements. Fabric shall be delivered to the job site in such a manner as to facilitate handling and incorporation into the work without damage. Material shall be stored in such a manner as to prevent exposure to direct sunlight and damage by other construction activities.

Prior to the installation of the fabric, the application surface shall be cleared of debris, sharp objects and trees. Tree stumps shall be cut to the level of the ground surface. If the stumps cannot be cut to the ground level, they shall be completely removed. In the case of subgrades, all wheel tracks or ruts in excess of 3 in. (75 mm) in depth shall be graded smooth or otherwise filled with soil to provide a reasonably smooth surface.

Fabric may be installed on the application surface either by hand or by mechanical methods, provided that the fabric is not torn or the surface rutted.

Fabric of insufficient width or length to fully cover the specified area shall be lapped, or sewn. The minimum laps for lap only areas are 2 ft (600 mm) and for

sewn areas are 4 in. (100 mm). If sewn, the seam strength shall be equal to or exceed the minimum grab tensile strength of the fabric when tested wet.

210.04 Placement of Granular Blanket. The granular blanket shall be constructed to the width and depth required on the plans. Granular embankment, special shall be used in conjunction with the geotechnical fabric. The material shall be back dumped on the fabric in a sequence of operations beginning at the outer edges of the treatment area with subsequent placement towards the middle.

Placement of material on the fabric shall be accomplished by spreading dumped material off of previously placed material with a bulldozer blade or endloader, in such a manner as to prevent tearing or shoving of the cloth. Dumping of material directly on the fabric will only be permitted to establish an initial working platform. No vehicles or construction equipment shall be allowed on the fabric prior to placement of the granular blanket.

The granular material shall be placed to the full required thickness and compacted before any loaded trucks are allowed on the blanket.

Fabric which is damaged during installation or subsequent placement of granular material, due to failure of the Contractor to comply with these provisions, shall be repaired or replaced.

Torn fabric may be patched in place by cutting and placing a piece of the same fabric over the tear. The dimensions of the patch shall be at least 2 ft (600 mm) larger than the tear in each direction, and shall be weighted or otherwise secured to prevent the granular material from causing lap separation.

210.05 Method of Measurement. Geotechnical fabric will be measured for payment in place and the area computed in square yards (square meters). Granular blanket will be measured for payment in tons (metric tons) or in cubic yards (cubic meters) according to Article 311.08.

210.06 Basis of Payment. Geotechnical fabric will be paid for at the contract unit price per square yard (square meter) for GEOTECHNICAL FABRIC FOR GROUND STABILIZATION.

The granular blanket will be paid for at the contract unit price per ton (metric ton) for GRANULAR EMBANKMENT, SPECIAL, or at the contract unit price per cubic yard (cubic meter) for GRANULAR EMBANKMENT, SPECIAL.

SECTION 211. TOPSOIL AND COMPOST

211.01 Description. This work shall consist of furnishing, excavating, and placing topsoil, special types of topsoil, or compost.

211.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Topsoil (Furnished from outside of the R.O.W.)	1081.05(a)
(b) Compost	1081.05(b)

CONSTRUCTION REQUIREMENTS

211.03 Furnishing and Excavating Topsoil. Topsoil shall be obtained from within the limits of the right-of-way at the locations and to the depths designated on the plans or approved by the Engineer. This topsoil shall be stockpiled at locations approved by the Engineer. When special types of topsoil are specified, each type shall be handled separately and not allowed to mix with any other material. When special types of topsoil (Hydric, Prairie or Woodland) are specified, the seeds and plants within the excavated special topsoils are desirable to maintain. To keep these seeds and plants viable, the topsoil shall be excavated then placed as directed by the Engineer or as specified in the contract. If stockpiling cannot be avoided, special measures, such as watering the stockpile and planting a cover crop on the stockpile will be required as directed by the Engineer.

If additional topsoil is required to complete the contract to the lines, grades and the minimum thickness shown on the plans, the Contractor shall furnish any additional topsoil from areas outside the limits of the right-of-way. This additional topsoil obtained from outside the right-of-way shall be approved by the Engineer prior to its use.

In lieu of furnishing additional topsoil from areas outside the limits of the right-of-way, the Contractor may request permission to obtain the additional topsoil from areas within the limits of the right-of-way other than those shown on the plans.

211.04 Placing Topsoil and Compost. Topsoil shall not be placed until the area to be covered has been shaped, trimmed, and finished according to Section 212. All irregularities or depressions in the surface due to weathering or other causes shall be filled or smoothed out before the topsoil is placed. If the existing surface has become hardened or crusted, it shall be disked or raked or otherwise broken up so as to provide a bond with the lift of topsoil to be applied.

When compost is specified, it shall be placed at the specified depth on top of the topsoil. The Engineer will verify that the proper topsoil and compost depths have been applied. After verification of proper depth, the Contractor shall completely incorporate the compost into the topsoil by diskings or tilling.

211.05 Finishing. The surface of the topsoil or compost/topsoil blend shall be free from clods, stones, sticks and debris and shall be according to the lines, grades

and the minimum thickness shown on the plans. If required by the Engineer, one rolling of the entire surface shall be made.

211.06 Clearing Area and Disposal of Surplus Material. Upon completion of the work, all areas shall be cleared of equipment, debris, and excess material. Surplus or waste material resulting from construction operations shall be disposed of according to Article 202.03.

211.07 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Material excavated in excess of that required for the contract will not be measured for payment.

Topsoil excavation and placement shall be that material obtained from within the limits of the right-of-way and will be measured in cubic yards (cubic meters) in its original position. The volume will be computed by the method of average end areas. In no case will the width or depth used for the computations be greater than the dimensions shown on the plans unless such changes have been approved in writing by the Engineer. Topsoil excavation shall include the excavating, hauling, and stockpiling of the material in the locations approved by the Engineer. If the Contractor requests and the Engineer approves additional areas within the limits of the right-of-way for topsoil excavation other than shown on the plans, these added quantities will be deducted from the item of borrow excavation, furnished excavation, or earth excavation.

Topsoil furnish and place, and compost furnish and place shall be that material obtained from outside the right-of-way and will be measured in square yards (square meters).

Excavation and embankment quantities for the roadway have been computed on the basis of cut and fill to the subgrade of the topsoil.

211.08 Basis of Payment. This work will be paid for at the contract unit price per cubic yard (cubic meter) for TOPSOIL EXCAVATION AND PLACEMENT; per square yard (square meter) for TOPSOIL FURNISH AND PLACE, of the thickness specified; and per square yard (square meter) for COMPOST FURNISH AND PLACE, of the thickness specified.

SECTION 212. FINAL SHAPING, TRIMMING, AND FINISHING

212.01 Description. This work shall consist of the final shaping, trimming, and finishing of the roadway, the final finishing and cleaning up of the right-of-way, and completing the work for acceptance. This work is in addition to the requirements of Article 104.06.

CONSTRUCTION REQUIREMENTS

212.02 Grading Sections. When the contract does not include a surface or base course, the ditches shall be cleaned, all irregularities in the roadbed shall be smoothed out, depressions shall be filled, and the entire roadway shall be shaped, trimmed, and finished uniformly to the lines, grades, and cross sections shown on the plans, and the right-of-way cleaned up for final acceptance. The finished surface of the roadbed shall not vary from the lines, grades, and cross sections shown on the plans by more than 2 in. (50 mm).

212.03 Full Depth and Rigid Type Surface Sections. The roadway for concrete pavement, full-depth hot mix asphalt, or pavement with concrete base course and any hot mix asphalt shall be shaped, trimmed, and finished as follows.

- (a) Sections Not Previously Graded. The ditches shall be cleaned, and the entire roadway shall be shaped, trimmed, and finished uniformly to the lines, grades, and cross sections shown on the plans, and the right-of-way cleaned up for final acceptance.
- (b) Sections Previously Graded. Where it is not necessary to secure material from the backslopes of cuts and ditches to complete the earthwork in the roadbed; or where no work is indicated on the plans which will interfere with such slopes; or where the Contractor's operations do not disturb such slopes, no further work on the slopes will be required. If such slopes are disturbed by the Contractor's operations, the Contractor shall trim and reshape them.

In reshaping existing shoulders and medians, widening existing embankments, or raising existing low shoulders and medians, the Contractor shall construct or reshape the shoulders and medians according to Section 480.

Side slopes of fills shall be trimmed and shaped for a distance of 4 ft (1.2 m), measured from the edge of the shoulder toward the toe of the fill slope. The ditches shall be cleaned, and the right-of-way cleaned up for final acceptance.

212.04 Nonrigid Type Surface and Base Course Sections. The roadway for nonrigid type surfacings, such as aggregate surface course or any hot-mix asphalt surface course not built on a portland cement concrete base course, shall be shaped, trimmed, and finished.

After the surface or base course material has been placed, all additional construction operations shall be performed in such a manner that earth or other objectionable substances will not be deposited on the surface or base course material.

- (a) **Sections Not Previously Graded.** When the base course is constructed in a trench, all final shaping, trimming, and finishing of ditches, backslopes of cuts, and sideslopes of fills shall be completed to the lines, grades, and cross sections shown on the plans, and all shoulder material shall be roughed in before the base course material is placed.

All final shaping, trimming, and finishing of the roadbed shall be completed to the lines, grades, and cross sections shown on the plans, before the surfacing material is placed.

- (b) **Sections Previously Graded.** The backslopes of cuts and ditches and the sideslopes of fills shall be finished according to Article 212.03(b) before the base course material is placed.

When base course is constructed in a trench, all shoulder material shall be roughed in before the surface or base course material is placed.

All final shaping, trimming, and finishing of the roadbed shall be completed before the surfacing material is placed.

212.05 Finishing. All unsuitable material, debris, and rubbish, resulting from construction operations, or occurring within the right-of-way, and all stones or boulders more than 3 in. (75 mm) in largest dimension, shall be removed from the right-of-way and disposed of according to Article 202.03. The degree of finish for graded slopes outside of the roadbed shall be that which can be obtained by use of suitable mechanical equipment, with only such hand labor as special conditions may require.

Where the roadway has been resurfaced and as directed by the Engineer, any high areas in the existing earth shoulders that remain after resurfacing is complete which would entrap water adjacent to the pavement edge shall be bladed off. The existing earth shoulders shall be sloped to drain, but grading which requires additional material to conform to a uniform cross section will not be required. Immediately prior to final inspection, mowing of the right-of-way will be required at locations as directed by the Engineer.

212.06 Basis of Payment. Except for blading off high spots in the existing earth shoulders where the roadway has been resurfaced and for mowing immediately prior to final inspection, this work will not be measured or paid for separately, but shall be considered as included in the contract unit price for the particular type of surface course, base course or widening included in the contract. If surface course, base course or widening items are not included in the contract, the cost of final shaping, trimming and finishing shall be considered as included in the contract unit prices for the various items of earthwork.

Blading off high spots in the existing earth shoulders where the roadway has been resurfaced and mowing required immediately prior to final inspection will be paid for according to Article 109.04.

SECTION 213. EXPLORATION TRENCH

213.01 Description. This work shall consist of constructing a trench for the purpose of locating existing farm underdrains within the construction limits of the proposed improvement.

CONSTRUCTION REQUIREMENTS

213.02 General. The exploration trench shall be constructed at the locations shown on the plans or as directed by the Engineer.

The trench shall be not less than 52 in. (1.3 m) in depth, measured from the existing ground elevation. The width of the trench shall be sufficient to allow proper investigation of the entire trench.

When an existing farm underdrain is encountered, another trench shall be excavated on the opposite side of the proposed improvement to establish the line and grade of the existing farm underdrain. Broken tile shall be repaired immediately and no surface runoff shall be allowed to enter any tile.

After the trench has been inspected by the Engineer, the excavated material shall be used to backfill the trench. Any excess material shall be disposed of according to Article 202.03, and the area shall be shaped and trimmed according to Section 212.

When approved by the Engineer, the Contractor may use other means of locating existing farm underdrains.

213.03 Method of Measurement. The exploration trench will be measured for payment in feet (meters) of actual trench constructed.

213.04 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for EXPLORATION TRENCH, of the depth specified.

Other means of locating existing farm underdrains approved by the Engineer will be paid for according to Article 109.04.

SECTION 214. GRADING AND SHAPING DITCHES

214.01 Description. This work shall consist of grading and shaping existing ditches.

CONSTRUCTION REQUIREMENTS

214.02 General. All surplus, unstable, and unsuitable material shall be disposed of according to Article 202.03.

214.03 Method of Measurement. This work will be measured for payment in feet (meters) along the centerline of the ditch.

The volume of any unstable and/or unsuitable material removed will be measured for payment according to Article 202.07.

214.04 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for GRADING AND SHAPING DITCHES.

Removal and disposal of unstable and/or unsuitable material will be paid for according to Article 202.08.

LANDSCAPING

SECTION 250. SEEDING

250.01 Description. This work shall consist of preparing the seed bed and placing the seed and other materials required in seeding operations on the shoulders, slopes, and other areas.

250.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Seeds	1081.04
(b) Agricultural Ground Limestone	1081.07
(c) Fertilizer	1081.08

250.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Disk	1101.08(a)
(b) Slope Harrow	1101.08(b)
(c) Hydraulic Seeder	1101.08(c)
(d) Cultipacker	1101.08(d)
(e) Broadcast Seeders	1101.08(e)
(f) Tractor Drawn or Tractor Mounted Drop Seeders	1101.08(f)
(g) Rangeland Type Grass Drill and Interseeding Attachment	1101.08(g)
(h) Slit Seeder	1101.08(h)

CONSTRUCTION REQUIREMENTS

250.04 Fertilizer and Agricultural Ground Limestone Application. When specified for bare earth areas, fertilizer nutrients and agricultural ground limestone shall be uniformly spread over the designated areas immediately prior to seed bed preparation.

When specified for existing turf areas, fertilizer nutrients and agricultural ground limestone shall be uniformly spread over the designated areas during the spring, late summer, or early fall seasons. The Contractor shall restore any existing turf areas damaged by improper application of fertilizer nutrients or agricultural ground limestone.

When fertilizer is specified, 270 lb (300 kg) of fertilizer nutrients per acre (hectare) shall be applied at 1:1:1 ratio as follows.

Nitrogen Fertilizer Nutrients	90 lb/acre (100 kg/ha)
Phosphorus Fertilizer Nutrients	90 lb/acre (100 kg/ha)
Potassium Fertilizer Nutrients	90 lb/acre (100 kg/ha)

When agricultural ground limestone is specified, it shall be applied at a rate of 2 tons/acre (4.5 metric tons/ha) multiplied by the source correction factor.

250.05 Seed Bed Preparation. For bare earth seeding, seed bed preparation shall not be started until all requirements of Section 212 have been completed. The area to be seeded shall be worked to a minimum depth of 3 in. (75 mm) with a disk, tiller, or other equipment approved by the Engineer, reducing all soil particles to a size not larger than 2 in. (50 mm) in the largest dimension. The prepared surface shall be relatively free from weeds, clods, stones, roots, sticks, rivulets, gullies, crusting, and caking. If the area is to be covered by an erosion control blanket or turf reinforcement mat, the seed bed shall comply with the preparation requirements of Article 251.04 for erosion control blanket or Article 251.05 for turf reinforcement mat prior to application of seed. No seeds shall be sown until the seed bed has been approved by the Engineer.

Seed bed preparation will not be required for Class 7 Seeding if the soil is in a loose condition. Light disking shall be done if the soil is hard or caked.

For areas in which a stand of winter wheat exists, as a result of temporary erosion control seeding, disking will be required.

250.06 Seeding Methods. No seed shall be sown during high winds or when the ground is not in a proper condition for seeding, nor shall any seed be sown until the purity test has been completed for the seeds to be used, and shows that the seed meets the noxious weed seed requirements. All equipment shall be approved by the Engineer prior to being used. Prior to starting work, seeders and interseeders shall be calibrated and adjusted to sow seeds at the required seeding rate. Equipment shall be operated in a manner to ensure complete coverage of the entire area to be seeded or interseeded. The Engineer shall be notified 48 hours prior to beginning the seeding operations so that the Engineer may determine by trial runs that a calibration of the seeder will provide uniform distribution at the specified rate per acre (hectare).

When seed or fertilizer is applied with a hydraulic seeder, the rate of application shall be not less than 1000 gal (9500 L) of slurry per acre (hectare). This slurry shall contain the proper quantity of seed or fertilizer nutrients specified per acre (hectare). When using a hydraulic seeder, the fertilizer nutrients and seed shall be applied in two separate operations.

All legumes (clover and alfalfa) shall be inoculated with the proper bacteria in the amounts and manner recommended by the manufacturer of the inoculant before sowing or being mixed with other seeds for sowing. The inoculant shall be furnished by the Contractor and shall be approved by the Engineer. The seed shall be sown as soon as possible after inoculation. Seed that has been standing more than 24 hours after inoculation shall be reinoculated before sowing. If legumes are applied by a hydraulic seeder, three times the normal amount of inoculant shall be used.

- (a) Bare Earth Seeding. Bare earth seeding shall be done using the following methods unless otherwise specified or directed by the Engineer.
 - (1) Seeding Classes 1, 2, and 6 shall be sown with a machine that mechanically places the seed in direct contact with the soil, packs, and covers the seed in one continuous operation.
 - (2) Seeding Class 4 shall be sown with a rangeland type grass drill.
 - (3) Seeding Class 3 may be sown with a hydraulic seeder.
 - (4) Seeding Classes 5 and 7 shall be sown with a hydraulic seeder or rangeland type grass drill.

Broadcasting or hydraulic seeding will be allowed as approved by the Engineer on steep slopes (over 1:3 (V:H)) or in inaccessible areas where use of the equipment specified is physically impossible. When broadcast seeders are used for Seeding Class 3 or 4, the individual seeds comprising the seeding mixture shall be sown separately. When Seeding Class 7 is used as an erosion control measure to establish temporary cover, hand broadcasting of the seed or other methods approved by the Engineer will be allowed.

- (b) Interseeding. Interseeding is the seeding of areas of existing turf. Prior to interseeding, all areas of existing turf to be interseeded, except as listed below, shall be mowed one or more times to a height of not more than 3 in. (75 mm). The equipment used shall be capable of completely severing all growth at the cutting height and distributing it evenly over the mowed area. The cut material shall not be windrowed or left in a lumpy or bunched condition. Additional mowing may be required, as directed by the Engineer, on certain areas in order to disperse the mowed material and allow penetration of the seed. The Contractor will not be required to mow within 1 ft (300 mm) of the right-of-way fence, continuously wet ditches and drainage ways, slopes 1:3 (V:H) and greater, or areas which may be designated as not mowable by the Engineer.

Debris encountered during the mowing and interseeding operations which hamper the operation or are visible from the roadway shall be removed and

disposed of according to Article 250.05. Damage to the right-of-way and turf, such as ruts or wheel tracks more than 2 in. (50 mm) in depth, shall be repaired to the satisfaction of the Engineer prior to the time of interseeding.

All seeding classes shall be interseeded using a rangeland type grass drill with an interseeding attachment, except the following.

- (1) When specified in the plans or directed by the Engineer, a slit seeder shall be used to interseed Class 1 or Class 2 seed.
- (2) Broadcasting or hydraulic seeding will be allowed as approved by the Engineer on steep slopes (1:3 (V:H) or steeper) or in inaccessible areas where use of the equipment specified is physically impossible. Sufficient water shall be applied to these areas to wash the seed down to the soil.

When broadcast seeders are used for Seeding Class 3 or 4, the individual seeds comprising the seeding mixture shall be sown separately.

250.07 Seeding Mixtures. The classes of seeding mixtures and combinations of mixtures will be designated in the plans.

When an area is to be seeded with two or more seeding classes, those mixtures shall be applied separately on the designated area within a seven day period. All seeding shall occur prior to placement of mulch cover. A Class 7 mixture can be applied at any time prior to applying any seeding class or added to them and applied at the same time.

TABLE 1 - SEEDING MIXTURES		
Class - Type	Seeds	lb/acre (kg/hectare)
1 Lawn Mixture 7/	Ky Bluegrass Perennial Ryegrass Creeping Red Fescue	100 (110) 60 (70) 40 (50)
1A Salt Tolerant Lawn Mixture 7/	Bluegrass Perennial Ryegrass Red Fescue (Audubon, Sea Link, or Epic) Hard Fescue (Rescue 911, Spartan II, or Reliant IV) Fults Salt Grass 1/ or Salty Alkaligrass	60 (70) 20 (20) 20 (20) 20 (20) 60 (70)
1B Low Maintenance Lawn Mixture 7/	Fine Leaf Turf-Type Fescue 3/ Perennial Ryegrass Red Top Creeping Red Fescue	150 (170) 20 (20) 10 (10) 20 (20)
2 Roadside Mixture 7/	Tall Fescue (Inferno, Tarheel II, Quest, Blade Runner, or Falcon IV) Perennial Ryegrass Creeping Red Fescue Red Top	100 (110) 50 (55) 40 (50) 10 (10)
2A Salt Tolerant Roadside Mixture 7/	Tall Fescue (Inferno, Tarheel II, Quest, Blade Runner, or Falcon IV) Perennial Ryegrass Red Fescue (Audubon, Sea Link, or Epic) Hard Fescue (Rescue 911, Spartan II, or Reliant IV) Fults Salt Grass 1/ or Salty Alkaligrass	60 (70) 20 (20) 30 (20) 30 (20) 60 (70)
3 Northern Illinois Slope Mixture 7/	Elymus Canadensis (Canada Wild Rye) Perennial Ryegrass Alsike Clover 2/ Desmanthus Illinoensis (Illinois Bundleflower) 2/, 5/ Andropogon Scoparius (Little Bluestem) 5/ Bouteloua Curtipendula (Side-Oats Grama) Fults Salt Grass 1/ or Salty Alkaligrass Oats, Spring Slender Wheat Grass 5/ Buffalo Grass (Cody or Bowie) 4/, 5/, 9/	5 (5) 20 (20) 5 (5) 2 (2) 12 (12) 10 (10) 30 (35) 50 (55) 15 (15) 5 (5)
3A Southern Illinois Slope Mixture 7/	Perennial Ryegrass Elymus Canadensis (Canada Wild Rye) 5/ Panicum Virgatum (Switchgrass) 5/ Andropogon Scoparius (Little Blue Stem) 5/ Bouteloua Curtipendula (Side-Oats Grama) 5/ Petalostemum Candidum (White Prairie Clover) 5/ Rudbeckia Hirta (Black-Eyed Susan) 5/ Oats, Spring	20 (20) 20 (20) 10 (10) 12 (12) 10 (10) 5 (5) 5 (5) 5 (5) 50 (55)

Class - Type		Seeds	lb/acre (kg/hectare)
4	Native Grass 6/, 8/	Andropogon Gerardi (Big Blue Stem) 5/	4 (4)
		Andropogon Scoparius (Little Blue Stem) 5/	5 (5)
		Bouteloua Curtipendula (Side-Oats Grama) 5/	5 (5)
		Elymus Canadensis (Canada Wild Rye) 5/	1 (1)
		Panicum Virgatum (Switch Grass) 5/	1 (1)
		Sorghastrum Nutans (Indian Grass) 5/	2 (2)
		Annual Ryegrass	25 (25)
		Oats, Spring	25 (25)
		Perennial Ryegrass	15 (15)
4A	Low Profile Native Grass 6/, 8/	Andropogon Scoparius (Little Blue Stem) 5/	5 (5)
		Bouteloua Curtipendula (Side-Oats Grama) 5/	5 (5)
		Elymus Canadensis (Canada Wild Rye) 5/	1 (1)
		Sporobolus Heterolepis (Prairie Dropseed) 5/	0.5 (0.5)
		Annual Ryegrass	25 (25)
		Oats, Spring	25 (25)
		Perennial Ryegrass	15 (15)
4B	Wetland Grass and Sedge Mixture 6, 8/	Annual Ryegrass	25 (25)
		Oats, Spring	25 (25)
		Wetland Grasses (species below)	6 (6)
	<u>Species:</u>		<u>% By Weight</u> 5/
	Calamagrostis Canadensis (Blue Joint Grass)		12
	Carex lacustris (Lake-Bank Sedge)		6
	Carex slipata (Awl-Fruited Sedge)		6
	Carex stricta (Tussock Sedge)		6
	Carex vulpinoidea (Fox Sedge)		6
	Eleocharis acicularis (Needle Spike Rush)		3
	Eleocharis obtusa (Blunt Spike Rush)		3
	Glyceria striata (Fowl Manna Grass)		14
	Juncus effusus (Common Rush)		6
	Juncus tenuis (Slender Rush)		6
	Juncus torreyi (Torrey's Rush)		6
	Leersia oryzoides (Rice Cut Grass)		10
	Scirpus acutus (Hard-Stemmed Bulrush)		3
	Scirpus atrovirens (Dark Green Rush)		3
	Scirpus fluviatilis (River Bulrush)		3
	Scirpus validus (Softstem Bulrush)		3
	Spartina pectinata (Cord Grass)		4

Class - Type	Seeds	lb/acre (kg/hectare)
5 Forb with Annuals Mixture	Annuals Mixture (Below) 6/, 8/ Forb Mixture (Below) 6/, 8/	1 (1) 10 (10)
Annuals Mixture - Mixture not exceeding 25 % by weight of any one species, of the following:		
Coreopsis lanceolata (Sand Coreopsis)		
Chrysanthemum maximum (Shasta Daisy)		
Gaillardia pulchella (Blanket Flower)		
Ratibida columnitera (Long-Headed Coneflower)		
Rudbeckia hirta (Black-Eyed Susan)		
Forb Mixture - Mixture not exceeding 5 % by weight PLS of any one species, of the following:		
Amorpha canescens (Lead Plant) 2/		
Anemone cylindrica (Thimble Weed)		
Asclepias tuberosa (Butterfly-Weed)		
Aster azureus (Sky Blue Aster)		
Aster laevis (Smooth Aster)		
Aster novae-angliae (New England Aster)		
Baptisia leucantha (White Wild Indigo) 2/		
Coreopsis palmata (Prairie Coreopsis)		
Echinacea pallida (Pale Purple Coneflower)		
Eryngium yuccifolium (Rattlesnake Master)		
Helianthus mollis (Downy Sunflower)		
Heliopsis helianthoides (Ox-Eye)		
Liatris aspera (Rough Blazing Star)		
Liatris pycnostachya (Prairie Blazing Star)		
Monarda fistulosa (Prairie Bergamont)		
Parthenium integrifolium (WildQuinine)		
Petalostemum candidum (White Prairie Clover) 2/		
Petalostemum purpureum (Purple Prairie Clover) 2/		
Physostegia virginiana (False Dragonhead)		
Potentilla arguta (Prairie Cinquefoil)		
Ratibida pinnata (Yellow Coneflower)		
Rudbeckia subtomentosa (Fragrant Coneflower)		
Silphium laciniatum (Compass Plant)		
Silphium terebinthinaceum (Prairie Dock)		
Solidago rigida (Rigid Goldenrod)		
Tradescantia ohiensis (Spiderwort)		
Veronicastrum virginicum (Culver's Root)		

Class - Type		Seeds	lb/acre (kg/hectare)
5A	Large Flower Native Forb Mixture 6/, 8/	Forb Mixture (see below)	5 (5)
		<u>Species:</u>	<u>% By Weight 5/</u>
		Aster novae-angliae (New England Aster)	5
		Echinacea pallida (Pale Purple Coneflower)	10
		Helianthus mollis (Downy Sunflower)	10
		Heliopsis helianthoides (Ox-Eye)	10
		Liatris pycnostachya (Prairie Blazing Star)	10
		Ratibida pinnata (Yellow Coneflower)	5
		Rudbeckia hirta (Black-Eyed Susan)	10
		Silphium laciniatum (Compass Plant)	10
		Silphium terebinthinaceum (Prairie Dock)	20
		Solidago rigida (Rigid Goldenrod)	10
5B	Wetland Forb	Forb Mixture (see below) 6/, 8/	2 (2)
		<u>Species:</u>	<u>% By Weight 5/</u>
		Acorus calamus (Sweet Flag)	3
		Angelica atropurpurea (Angelica)	6
		Asclepias incarnata (Swamp Milkweed)	2
		Aster puniceus (Purple Stemmed Aster)	10
		Bidens cernua (Beggarticks)	7
		Eupatorium maculatum (Spotted Joe Pye Weed)	7
		Eupatorium perfoliatum (Boneset)	7
		Helenium autumnale (Autumn Sneezeweed)	2
		Iris virginica shrevei (Blue Flag Iris)	2
		Lobelia cardinalis (Cardinal Flower)	5
		Lobelia siphilitica (Great Blue Lobelia)	5
		Lythrum alatum (Winged Loosestrife)	2
		Physostegia virginiana (False Dragonhead)	5
		Polygonum pensylvanicum (Pennsylvania Smartweed)	10
		Polygonum lapathifolium (Curlytop Knotweed)	10
		Pycnanthemum virginianum (Mountain Mint)	5
		Rudbeckia laciniata (Cut-leaf Coneflower)	5
		Solidago riddellii (Riddell Goldenrod)	2
		Sparganium eurycarpum (Giant Burreed)	5
6	Conservation Mixture	Andropogon Scoparius (Little Blue Stem) 5/ Elymus Canadensis (Canada Wild Rye) 5/ Buffalo Grass (Cody or Bowie) 4/, 5/, 9/ Vernal Alfalfa 2/ Oats, Spring	5 (5) 2 (2) 5 (5) 15 (15) 48 (55)
6A	Salt Tolerant Conservation Mixture	Andropogon Scoparius (Little Blue Stem) 5/ Elymus Canadensis (Canada Wild Rye) 5/ Buffalo Grass (Cody or Bowie) 4/, 5/, 9/ Vernal Alfalfa 2/ Oats, Spring Fults Salt Grass 1/ or Salty Alkaligrass	5 (5) 2 (2) 5 (5) 15 (15) 48 (55) 20 (20)
7	Temporary Turf Cover Mixture	Perennial Ryegrass Oats, Spring 4/	50 (55) 64 (70)

Notes:

- 1/ Fulus pucinnellia distans.
- 2/ Legumes - inoculation required.
- 3/ Specific variety as shown in the plans or approved by the Engineer.
- 4/ Other seeds may be used if approved by the Engineer.
- 5/ PLS = Pure Live Seed to be used.
- 6/ Fertilizer not required.
- 7/ In Districts 1 through 6, the planting times shall be April 1 to June 15 and August 1 to November 1. In Districts 7 through 9, the planting times shall be March 1 to June 1 and August 1 to November 15. Seeding may be performed outside these dates provided the Contractor guarantees a minimum of 75 percent uniform growth over the entire seeded area(s) after a period of establishment. Inspection dates for the period of establishment will be as follows: Seeding conducted in Districts 1 through 6 between June 16 and July 31 will be inspected after April 15 and seeding conducted between November 2 and March 31 will be inspected after September 15. Seeding conducted in Districts 7 through 9 between June 2 and July 31 will be inspected after April 15 and seeding conducted between November 16 and February 28 will be inspected after September 15. The guarantee shall be submitted to the Engineer in writing prior to performing the work. After the period of establishment, areas not exhibiting 75 percent uniform growth shall be interseeded or reseeded, as determined by the Engineer, at no additional cost to the Department.
- 8/ Planting times May 15 to June 30 and October 15 to December 1.
- 9/ Seed shall be primed with KNO_3 to break dormancy and dyed to indicate such.

Variation in the Class 4 or 5 seed quantities or varieties will be allowed in the event of a crop failure or other unforeseen conditions. The Contractor shall provide for the approval of the Engineer a written description of the changed Class 4 or 5 Mixture, the reasons for the change, and the name of the seed supplier.

250.08 Selective Mowing Stakes. Selective mowing stakes shall be installed to delineate areas to be seeded or interseeded with Class 4 or 5 mixtures. Selective mowing stakes shall be steel posts as described in Article 1081.13(a). The selective mowing stakes shall be driven into the ground to a height of 3 1/2 ft (1.1 m) above the ground at locations shown on the plans and as directed by the Engineer.

250.09 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirement for use of contract quantities shall be according to Article 202.07(a).
- (b) Measured Quantities. Seeding of the class specified and mowing will be measured in acres (hectares) of surface area seeded or mowed.

The exact locations of seeding and mowing will be determined in the field by the Engineer, and the quantities will be adjusted accordingly. Fertilizer will be measured by weight in pounds (kilograms) of actual nutrients. The percent of nutrients equals the guaranteed analysis on the bag. The

following formula will be used to determine the pounds (kilograms) of fertilizer nutrients applied.

$$\begin{aligned} & \text{(Total pounds (kilograms) of mixed fertilizer)} \\ & \quad \times \\ & \text{(Percentage of each nutrient in the fertilizer applied)} \\ & = \text{pounds (kilograms) of each fertilizer nutrient} \end{aligned}$$

Agricultural Ground Limestone will be measured by weight in tons (metric tons) of Agricultural Ground Limestone having an effective neutralizing value of 67.5 (four year base, a source correction factor of 1.0). Applied quantity shall be the plan quantity multiplied by the source correction factor. The pay quantity will be the applied quantity divided by the source correction factor.

Payment will not be made for fertilizer nutrients in excess of 103 percent or agricultural ground limestone in excess of 108 percent of the amounts specified by the Engineer.

Selective mowing stakes will be measured as each in place.

250.10 Basis of Payment. This work will be paid for at the contract unit price per acre (hectare) for SEEDING or INTERSEEDING of the Class specified; at the contract unit prices per pound (kilogram) for NITROGEN FERTILIZER NUTRIENT, PHOSPHORUS FERTILIZER NUTRIENT and POTASSIUM FERTILIZER NUTRIENT; and at the contract unit price per ton (metric ton) for AGRICULTURAL GROUND LIMESTONE.

Mowing will be paid for at the contract unit price per acre (hectare) for MOWING. Only the initial mowing will be paid for. Any subsequent mowing required to obtain a height of not more than 3 in. (75 mm) or to disperse mowed material will be considered as included in the cost of the initial mowing.

Selective Mowing Stakes will be paid for at the contract unit price per each for SELECTIVE MOWING STAKES.

SECTION 251. MULCH

251.01 Description. This work shall consist of furnishing, transporting, and placing mulch, erosion control blanket, or turf reinforcement mat over seeded areas.

251.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Compost	1081.05(b)
(b) Mulch	1081.06(a)
(c) Chemical Mulch Binder	1081.06(a)(3)
(d) Chemical Compost Binder	1081.06(a)(4)
(e) Excelsior Blanket	1081.10(a)
(f) Knitted Straw Mat	1081.10(b)
(g) Heavy Duty Erosion Control Blanket	1081.10(c)
(h) Wire Staples	1081.10(d)
(i) Wood Stakes	1081.10(e)
(j) Coconut Fiber	1081.10(f)
(k) Turf Reinforcement Mat	1081.10(g)

CONSTRUCTION REQUIREMENTS

251.03 Mulch. Within 24 hours of seed placement, mulch by one of the following methods shall be placed on the areas specified. On slopes steeper than 1:3 (V:H), mulch shall be applied the same day as seeded. Mulch shall be applied uniformly at the rate specified.

- (a) Method 1. This method shall consist of hand or machine application of straw mulch at the rate of 2 tons/acre (4.5 metric tons/ha). The mulch shall be loose enough to permit air to circulate but compact enough to reduce erosion. If baled mulch material is used, care shall be taken that the material is in a loosened condition and contains no lumps or knots of compacted material.
- (b) Method 2. This method shall consist of placing and stabilizing straw at the rate of 2 tons/acre (4.5 metric tons/ha) over seeded areas. All requirements of Method 1 must be met plus the mulch shall be thoroughly stabilized. The Contractor has the option of any of the following procedures for stabilizing the straw.
 - (1) Procedure 1. This procedure shall consist of anchoring the straw into the soil by means of a mechanical stabilizer with dull blades or disks. These blades or disks shall be without camber, approximately 20 in. (500 mm) in diameter, notches spaced at approximately 8 in. (200 mm) intervals and equipped with scrapers. The stabilizer shall be approximately 1000 lb (450 kg), have a working width not exceeding 72 in. (1.8 m), and shall be equipped with a ballast compartment, so that when directed, the weight (mass) can be increased.

- (2) Procedure 2. This procedure shall consist of stabilizing the straw with an approved mulch blower followed immediately by an overspray application of light-duty hydraulic mulch. The hydraulic mulch shall be according to Article 251.03(c) except that it shall be applied as a slurry of 900 lb (1020 kg) of mulch and 1000 gal (9500 L) of water per acre (hectare) using a hydraulic mulch applicator. The light-duty hydraulic mulch shall be agitated a minimum of five minutes before application and shall be agitated during application. The light-duty hydraulic mulch shall be applied from opposing directions to ensure even coverage.
- (3) Procedure 3. This procedure shall consist of stabilizing the straw with a chemical mulch binder. The chemical mulch binder may be applied simultaneously with the straw or as an overspray.
- a. Simultaneous Application. The coated straw shall be placed by equipment which will blow or eject, by means of a constant air stream, controlled quantities of straw and binder in a uniform pattern. The binder shall be introduced into the air stream of the machine by means of a spray which will partially coat the straw with a spotty tack. If the straw is excessively cut or broken, corrective measures shall be taken.
 - b. Overspray Application. The overspray application shall be performed according to Procedure 2.

The chemical mulch binder shall be approved by the Engineer and shall be applied at the rate recommended by the supplier and approved by the Engineer.

- (c) Method 3. This method shall consist of the machine application of a light-duty hydraulic mulch. Seeding shall be conducted as a separate operation and shall not be added to the hydraulic mulch slurry. Hydraulic mulch shall not be applied when the ambient temperature is at or below freezing. To achieve full and even coverage, the hydraulic mulch shall be applied from two opposing directions. Mixing and application rates shall be according to the manufacturer's recommendations and meet the minimum application rates set in Article 1081.06(a)(2).
- (d) Method 3A. This method shall consist of the machine application of a heavy-duty hydraulic mulch. Seeding shall be conducted as a separate operation and shall not be added to the hydraulic mulch slurry. The hydraulic mulch shall not be applied when the ambient temperature is at or below freezing. To achieve full and even coverage, the hydraulic mulch shall be applied from two opposing directions. Mixing and application rates shall be according to the manufacturer's recommendations and meet the minimum application rates set in Article 1081.06(a)(2). The heavy-duty hydraulic mulch shall be applied using a mechanically agitated hydraulic mulching machine.
- (e) Method 4. This method shall consist of applying compost combined with a performance additive designed to bind/stabilize the compost. The

compost/performance additive mixture shall be applied to the surface of the slope using a pneumatic blower at a depth of 2 in. (50 mm).

Following the mulching operation, foot and vehicular traffic, or the movement of equipment over the mulched area shall be prohibited. At any location where mulching has been displaced by any Contractor's equipment or personnel, the seeding and mulch or other work damaged as a result of that displacement shall be repaired or replaced immediately.

251.04 Erosion Control Blanket. Erosion control blanket may be placed using either excelsior blanket or knitted straw blanket. Within 24 hours of seed placement, blanket shall be placed on the areas specified. Prior to placing the blanket, the areas to be covered shall be relatively free of rocks or clods over 1 1/2 in. (40 mm) in diameter, and sticks or other foreign material which will prevent the close contact of the blanket with the seed bed. If, as a result of rain, the prepared seed bed becomes crusted or eroded, or if eroded places, ruts, or depressions exist for any reason, the Contractor shall rework the soil until it is smooth and reseed such areas which are reworked.

After the area has been properly shaped, fertilized, and seeded, the blanket shall be laid out flat, evenly, and smoothly, without stretching the material. The excelsior and knitted straw blankets shall be placed so that the netting is on the top and the fibers are in contact with the soil. The heavy duty blankets shall be placed so that the heavy duty extruded plastic mesh is on the bottom.

For placement in ditches, the erosion control blanket shall be applied parallel to the centerline of the ditch so that there are no longitudinal seams within 2 ft (600 mm) of the bottom centerline of the ditch. The blanket shall be toed in on the upslope edge and shingled or overlapped with the flow.

On slopes, the blanket shall be applied either horizontally or vertically to the contour, toed in on the upslope edge, and shingled or overlapped with the flow.

When placed adjacent to the roadway, blankets shall be toed in along the edge of shoulder.

Anchoring the blankets shall be according to the manufacturer's specifications.

251.05 Turf Reinforcement Mat (TRM). The TRM shall be specifically manufactured for both temporary and permanent erosion control, revegetation, and the reduction of water velocities in ditches and overflows. TRM shall be placed the same day as seed placement. Prior to placing the TRM, the areas to be covered shall be relatively free of rocks or clods over 1 1/2 in. (40 mm) in diameter, and sticks or other foreign material which will prevent the close contact of the mat with the seed bed. If, as a result of rain, the prepared seed bed becomes crusted, or if eroded places, ruts, or depressions exist for any reason, the Contractor shall rework the soil until it is smooth and reseed such areas which are reworked. The TRM shall be installed according to the manufacturer's recommendations.

251.06 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirement for use of contract quantities shall be according to Article 202.07(a).
- (b) Measured Quantities. Mulch Methods 1, 2, 3, 3A, and 4 will be measured for payment in place in acres (hectares) of surface area mulched. Erosion control blanket, heavy duty erosion control blanket, and turf reinforcement mat will be measured for payment in square yards (square meters).

251.07 Basis of Payment. This work will be paid for at the contract unit price per acre (hectare) for MULCH, METHOD 1; MULCH, METHOD 2; MULCH, METHOD 3; MULCH METHOD 3A; MULCH, METHOD 4; and at the contract unit price per square yard (square meter) for EROSION CONTROL BLANKET, HEAVY DUTY EROSION CONTROL BLANKET, or TURF REINFORCEMENT MAT.

SECTION 252. SODDING

252.01 Description. This work shall consist of preparing the ground surface and furnishing and placing sod and other materials required in the sodding operations.

252.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Sod	1081.03
(b) Salt Tolerant Sod	1081.03(b)
(c) Agricultural Ground Limestone	1081.07
(d) Fertilizer	1081.08

CONSTRUCTION REQUIREMENTS

252.03 Ground Preparation. The area to be sodded shall be finished according to Section 212 before sodding operations are begun. Immediately prior, but not in excess of 24 hours before the sod is placed, the soil surface shall be worked until it is free from debris, washes, gullies, clods and stones. The surface shall be worked to a depth of not less than 3 in. (75 mm) with a disk, tiller or other equipment approved by the Engineer. Prepared surface shall be finished to a fine smooth finish free of irregularities. Finished ground elevations shall allow for the thickness of sod to match grade of existing turf or structures.

All soil surfaces shall be moist when the sod is placed. When directed by the Engineer, the Contractor shall be required to apply water to dry soil surfaces at a minimum rate of 1 gal/sq yd (5 L/sq m) immediately prior to placing the sod.

When specified, agricultural ground limestone and fertilizer nutrients shall be applied at the designated rates over the areas to be sodded.

When fertilizer is specified, 180 lb (210 kg) of fertilizer nutrients per acre (hectare) shall be applied over the areas to be sodded at a 1:1:1 ratio as follows.

Nitrogen Fertilizer Nutrients	60 lb/acre (70 kg/ha)
Phosphorus Fertilizer Nutrients	60 lb/acre (70 kg/ha)
Potassium Fertilizer Nutrients	60 lb/acre (70 kg/ha)

252.04 Sodding Time. Sod shall be placed when the ground is in a workable condition and temperatures are less than 80 °F (26 °C). Sod shall not be placed when the sod or ground surface is frozen. Sod shall not be placed during the months of July and August.

252.05 Transportation. All sod shall be properly protected during transportation to maintain it in a live, healthy condition. Sod cut for more than 48 hours shall only be used with the approval of the Engineer. Any sod that has dried out, has heated to over 100 °F (38 °C), or is frozen prior to placing will be rejected and shall be immediately removed from the jobsite by the Contractor.

252.06 Placing Sod. The sod shall be placed on the prepared surface with the edges in close contact and alternate courses staggered.

In ditches, the sod shall be placed with the longer dimension perpendicular to the flow of water in the ditch. On slopes, starting at the bottom of the slope, the sod shall be placed with the longer dimension parallel to the contours of the ground. The exposed edges of sod shall be buried flush with the adjacent soil.

On slopes where the sod may be displaced during sodding operations, the workmen shall work from ladders or treaded planks.

252.07 Staking Sod. The sod shall be staked on all slopes of 1:2 (V:H) or steeper. Sod shall be staked with not less than four stakes per sq yd (sq m) with at least one stake for each piece of sod. Stakes shall be a minimum of 6 in. (150 mm) long. Stakes shall be installed so that they hold the sod firmly in place yet present no danger to pedestrians or mowing crews. The type of stake and the method of installation shall meet the approval of the Engineer.

252.08 Sod Watering. Within two hours after the sod has been placed, water shall be applied at a rate of 5 gal/sq yd (25 L/sq m). Additional water shall be applied every other day at a rate of 3 gal/sq yd (15 L/sq m) for a total of 15 additional waterings. During periods exceeding 80 °F (26 °C) or subnormal rainfall, the schedule of additional waterings may be altered with the approval of the Engineer.

The Contractor shall have on hand enough equipment to completely water all sodded areas in two days at the watering rates specified above. The Engineer will make periodic checks of the Contractor's watering equipment to determine its adequacy and operating condition.

All watering described shall be done with a spray application. An open end hose will not be acceptable. The method of watering shall meet the approval of the Engineer.

252.09 Supplemental Watering. During periods exceeding 80 °F (26 °C) or subnormal rainfall, supplemental watering may be required after the initial and additional waterings. Supplemental watering shall be performed when directed by the Engineer. Water shall be applied at the rate specified by the Engineer within 24 hours of notice.

252.10 Disposal of Surplus Material. Surplus and waste materials resulting from sodding operations shall be disposed of according to Article 202.03.

252.11 Inspection. The Contractor shall notify the Engineer of the localities from which the sod is to be obtained so that an authorized representative may inspect the fields for approval.

A copy of the inspection certificate required by law to this effect shall accompany each shipment and on arrival shall be filed with the Engineer.

With every shipment of salt tolerant sod, the Contractor shall provide to the Engineer a letter of certification from an authorized representative of the nursery stating that the seed mixture used in the sod conforms to the specifications.

252.12 Method of Measurement. Sodding will be measured for payment in place and the area computed in square yards (square meters). To be acceptable for final payment, the sod shall be growing in place for a minimum of 30 days in a live, healthy condition. When directed by the Engineer, any defective or unacceptable sod shall be removed, replaced, and watered.

Sod watering will not be measured for payment.

Supplemental watering will be measured for payment in units of 1000 gal (1000 L) of water applied on the sodded areas. Waterings performed in addition to those required by Article 252.08 or after the 30 day establishment period will be considered as supplemental watering.

Fertilizer and agricultural ground limestone will be measured for payment according to Article 250.09.

252.13 Basis of Payment. Sodding will be paid for at the contract unit price per square yard (square meter) for SODDING or SODDING, SALT TOLERANT according to the following schedule.

- (a) Initial Payment. Upon placement of sod, 25 percent of the pay item will be paid.
- (b) Final Payment. Upon acceptance of sod, the remaining 75 percent of the pay item will be paid.

Supplemental watering will be paid for at the contract unit price per unit for SUPPLEMENTAL WATERING.

Fertilizer and agricultural ground limestone will be paid for according to Article 250.10.

SECTION 253. PLANTING WOODY PLANTS

253.01 Description. This work shall consist of furnishing, transporting, and planting woody plants such as trees, shrubs, vines, and seedlings. The work shall also include all mulching, bracing, wrapping, watering, weeding, replacement of plants when required, and all work described.

253.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Trees, Shrubs, Vines, and Seedlings	1081.01
(b) Topsoil	1081.05(a)
(c) Mulch	1081.06(b)
(d) Bracing	1081.13
(e) Weed Barrier Fabric	1081.14

CONSTRUCTION REQUIREMENTS

253.03 Planting Time. Except for container grown items, plants must be dormant when delivered to the storage site or project.

In reference to the following planting dates, that portion of the State which lies north of a line formed by the southern boundaries of Hancock, Schuyler, Mason, Tazewell, McLean, Ford, and Iroquois Counties shall be considered the northern zone, while that portion of the State which lies south of this line shall be considered the southern zone.

Bare root plant material shall be planted only when the air temperatures exceed 35 °F (2 °C).

- (a) Spring Planting. This work shall be performed from the time the soil can be worked until the plant, under field conditions, is not dormant, except the following circumstances.
 - (1) Evergreen planting shall end April 1 in the southern zone and April 30 in the northern zone.
 - (2) Seedlings, broadleaf evergreens, vines and willow (*Salix* spp.), poplar (*Populus* spp.), oak (*Quercus* spp.), alder (*Alnus* spp.), birch (*Betula* spp.), hawthorn (*Crataegus* spp.), red maple (*Acer Rubrum*), cherry (*Prunus* spp.), and pear (*Pyrus* spp.) species shall be planted only during the spring planting season.
 - (3) The planting time may be extended for container grown plants, if the Engineer determines that the weather conditions are favorable.
- (b) Fall Planting. This work shall be performed from the time the plant becomes dormant until the ground cannot be satisfactorily worked, except that evergreen planting shall be performed between August 15 and October 15 in

the northern zone, and between September 1 and November 1 in the southern zone.

All plant material not planted according to the specified seasonal date shall require prior written approval from the Engineer. Failure to secure such approval shall result in the rejection of the plant material and replacement at no additional cost to the Department.

253.04 Digging of Plants. Plants shall not be dug until the Contractor is ready to transport them from their original locations to the site of the work or approved storage. The maximum time lapse between digging and being properly loaded, as defined in Article 1081.01 for delivery to the site of the work or being placed in approved storage, shall be four days for balled or burlapped plants and one day for bare root plants. They shall be dug with care, avoiding injury to the plants or loss or damage of the roots, particular attention being given to fibrous roots. Immediately after digging, roots shall be protected against drying out and freezing. Bare root plants shall be dug only when air temperatures exceed 35 °F (2 °C).

253.05 Transportation. During transportation, the Contractor shall exercise care to prevent injury and drying out of the plants. Upon arrival at the temporary storage location or the site of the work, plants will be inspected for proper shipping procedures as defined in Article 1081.01(d). Should the roots be dried out, large branches be broken, balls of earth be broken or loosened, or areas of bark be torn, the Engineer may reject the injured tree. When a tree has been so rejected, the Contractor shall at once remove it from the area of the work and replace it.

253.06 Temporary Storage. No plant shall remain in temporary storage over the summer. Plants delivered to the project that are not to be planted immediately shall be protected in the following manner.

- (a) **Bare Root Plants.** Plants may remain on the site of the work only 24 hours prior to being planted or placed in storage. During this 24 hour period, the Contractor shall continue to exercise care to prevent injury and drying out of the plants. The roots of plants to be placed in storage shall first be puddled in a paste solution of topsoil and water. The plants shall then be protected and kept moist by "heeling-in" the roots or by placing the plant in a cool moist storage building. The "heeling-in" procedure shall require the plants to be separated and the roots heeled in a suitable moist soil. If plants are stored in a building, the roots shall be covered with a suitable moist mulch. Winter storage of bare rooted plants will be allowed only in temperature and humidity controlled buildings. The Engineer shall approve the storage methods. The duration of storage, the method of storage and the materials used for mulch and "heeling-in" shall meet the approval of the Engineer.
- (b) **Balled and Burlapped Plants and Container Grown Plants.** Plants may remain on the site of the work only 72 hours prior to being planted or placed in storage.

Balled and burlapped plants shall be kept moist and their solidity carefully preserved. To prevent drying out or freezing, they shall be stored either in a cool moist storage building or placed in a compact group with a suitable

mulch material placed around and between the balls so they are completely covered.

Container grown plant material shall be kept moist by watering as directed by the Engineer. To prevent freezing, they shall be stored either in a cool moist storage building or placed in a compact group with a suitable mulch material placed around and between the containers so that they are completely covered.

The duration of storage, method of storage, and mulch material for balled and burlapped plant material and container grown plant material shall meet the approval of the Engineer.

253.07 Layout of Planting. The area to be planted shall be finished to line and grade before planting operations are begun. The Contractor shall furnish all marking flags for locating plants, and shall mark the common name of plants. The Engineer will place the marking flags and outline each area for mass or solid planting. Where seedlings are to be planted, the planting areas shall be delineated with selective mowing stakes. Selective mowing stakes shall be according to Article 250.08.

253.08 Excavation of Plant Holes. Plant holes shall be dug to the required depth and width, and shall be saucer shaped. On slopes, the depth of excavation will be measured at the center of the hole. The excess material excavated from the holes shall be spread in the immediate area as directed by the Engineer. The excavated material shall not be stockpiled on turf or in ditches. The sides of holes shall not be glazed or smooth.

- (a) Excavation for Trees. Holes for trees shall be dug at the location indicated by the marking flags. The diameter of the hole shall be equal to three times the diameter of the root ball and depth of the hole shall be equal to the depth of the root ball minus 2 in. (50 mm).
- (b) Excavation for Shrubs, Vines, and Seedlings. Holes for shrubs, vines, and seedlings shall be dug within the marked outline of the planting bed. The spacing of plants will be designated on the plans. Spacing shall be measured from center-to-center and alternate rows shall be staggered.

Prior to digging shrub and vine holes, existing vegetation on the area shall be mowed or treated with a non-selective, post emergent, non-residual herbicide approved by the Engineer. The area shall then be tilled to a minimum depth of 2 in. (50 mm) until free of debris, gullies, clods, weeds, stones, and roots.

Holes for shrubs shall be dug to a minimum diameter equal to three times the root ball diameter and equal to the root ball depth. Holes for vines shall be dug to a minimum diameter of 8 in. (200 mm) and depth of 8 in. (200 mm).

Immediately prior to planting seedlings, the existing grass and weed growth within the planting area shall be cut to a maximum height of 2 in. (50 mm). On slopes flatter than 1:3 (V:H), the soil adjacent to the plant row parallel to

the contour shall be prepared by cultivating or scalping to remove all grass and weed growth, in a continuous strip not less than 18 in. (450 mm) wide. The seedlings shall be planted in the center of this strip.

Holes for seedlings shall be made large enough to accommodate the root system with a spade, planting bar, or an approved mechanical tree planting machine. Individual holes for container grown plants shall be excavated to the same dimensions for comparable size balled and burlapped plant material.

253.09 Pruning. All pruning shall be performed by a professional arborist. Pruning shall be done in the presence of the Engineer and in such a manner as to preserve the natural growth habit of each plant. All pruning shall be done according to the current ANSI A300 (Part 1) – Pruning standard.

The ends of all broken and damaged roots of 1/4 in. (6 mm) or larger shall be pruned with a clean cut, removing only the injured portion. All broken branches, stubs, and improper cuts of former pruning shall be removed.

- (a) **Deciduous Trees.** Pruning shall consist of thinning the twigs or branches as dictated by the habit of growth of the various types of the trees to be pruned, and as directed by the Engineer. The leader and terminal buds shall not be cut unless directed by the Engineer.
- (b) **Deciduous Shrubs.** In general, shrubs shall be cut back to half of their height. Shrubs that are slow growing or do not sucker readily shall be pruned in the same manner as deciduous shade trees.
- (c) **Evergreens.** Evergreens shall not be pruned, except to remove broken or dead branches.

253.10 Planting Procedures. When directed by the Engineer, the backfill shall consist of suitable soil removed from the hole and topsoil as needed to match the level of the existing grade. If the existing soil is determined to be unsuitable, the backfill shall consist of topsoil as approved by the Engineer. Topsoil shall be stockpiled only at locations approved by the Engineer.

The backfill soil at the time of planting shall be capable of providing a sound growth environment and be in a loose, friable condition. At no time shall the backfill or other topsoil used on the job be stockpiled on turf or in ditches.

All plants shall be placed in a plumb position and set 2 in. (50 mm) higher than the depth they grew in the nursery. Prepared backfill shall be placed around the root system. Tamping or watering shall accompany the backfilling operation to eliminate air pockets.

Thorough watering of trees, shrubs, and vines, with a method approved by the Engineer, shall immediately follow the backfilling operation. This watering shall completely saturate the backfill and be performed during the same day of planting. After the ground settles, as a result of the watering, additional backfill shall be placed to match the level of the finished grade. Approved watering equipment shall be at the site of the work and in operational condition prior to starting the planting operation.

- (a) **Balled and Burlapped Plants.** After the plant is placed in the hole, all cords and burlap shall be removed from the trunk. Wire baskets shall be removed from at least the upper one half of the planting ball. All materials shall be disposed of properly.
- (b) **Container Grown Plants.** Prior to placing the plant in the hole, the container shall be removed with care so as not to disturb the ball of soil that contains the root system. During the planting operation, care shall be taken not to destroy the solidity of the ball of soil. Pots which will decompose in one growing season shall be removed to a point just below the surface of the ground.
- (c) **Bare Root Plants.** The roots shall be carefully spread in a natural position and prepared backfill shall be worked in around the roots so each root is individually packed to eliminate air pockets. The plant shall be gently raised and lowered to assure contact of the roots with the soil.
- (d) **Seedling Plants.** When seedlings are removed from storage for planting, they shall be transported to the planting site in containers of water and the roots shall be continuously immersed until planted. Any unplanted seedlings left at the end of each day shall be removed from the water, the roots wrapped in moist materials and the seedlings placed in storage.
 - (1) If holes are prepared according to Article 253.08, the roots shall be placed in the center of the hole and the backfill shall be compacted around the roots to eliminate air pockets. The backfill shall be saturated with water after the plant is placed.
 - (2) If an approved tree planting machine or a hand method that utilizes a planting bar or spade is used, no backfill will be required.
- (e) **Water Saucer.** All plants, except seedlings, placed individually and not specified to be bedded with other plants, shall have a water saucer constructed of soil equal to one half the diameter of the planting hole width and 4 in. (100 mm) in depth.

253.11 Mulch Cover. Within 30 days after planting, weed barrier fabric shall be placed around all plants and covered with mulch in the entire mulched bed or saucer area specified. Weed barrier and mulch will not be required for seedlings.

The fabric shall be cut as needed and fitted around the plant material. Wire staples, meeting the approval of the Engineer and driven at a 90 degree angle to the plane of the soil, shall be installed to hold the fabric in place. A minimum of one staple per square yard (square meter) is required. Strips of fabric shall overlap 6 in. (150 mm) at the seams. After placing the weed barrier fabric, the top surface of the fabric shall be clear of any topsoil, and mulch shall be placed in such a way as to completely cover the weed barrier to a depth of 4 in. (100 mm).

253.12 Wrapping. Within seven days after planting, a double lift of commercial screen wire mesh shall be wrapped around the trunk of all deciduous trees. Multi-stem or clump form trees shall have each stem wrapped separately. The

screen wire shall be secured to itself with staples or single wire strand tied to the mesh. The lower edge of the screen wire shall be in continuous contact with the ground and shall extend up a minimum of 36 in. (900 mm) or to the lowest major branch, whichever is less.

253.13 Bracing. All deciduous and evergreen trees, with the exception of multi-stem or clump form specimens, over 8 ft (2.5 m) in height shall require three 8 ft (2.5 m) long steel posts so placed that they are equidistant from each other and adjacent to the outside of the ball. The posts shall be driven vertically to a depth of 18 in. (450 mm) below the bottom of the hole. The anchor plate shall be aligned perpendicular to a line between the tree and the post. The tree shall be firmly attached to each post with a double guy of 14 gauge (2.03 mm) steel wire. The portion of the wire in contact with the tree shall be encased in a hose of a type and length approved by the Engineer.

During the life of the contract, if trees blow down, or are otherwise injured because of improper bracing, the Engineer may reject such injured trees, and the rejected trees shall be replaced.

253.14 Period of Establishment. Prior to being accepted, the plants shall endure a period of establishment. This period shall begin in June and end in September of the same year. To qualify for inspection, plants shall have been in place, in a live healthy condition, on or before June 1 of the year of inspection. To be acceptable, plants shall be in a live healthy condition, representative of their species, at the time of inspection in the month of September.

When the planting work is performed by a subcontractor, this delay in inspection and acceptance of plants shall not delay acceptance of the entire project and final payment due if the Contractor requires and receives from the subcontractor a third party performance bond naming the Department as obligee in the full amount of the planting quantities listed in the contract, multiplied by their contract unit prices. The bond shall be executed prior to acceptance and final payment of the non-planting items and shall be in full force and effect until final inspection and acceptance of all plants including replacements. Execution of the third party bond shall be the option of the prime Contractor.

The Department will assume the responsibility for all plant material found to be satisfactory at the time of inspection for successful completion of the period of establishment. Plants that do not meet the requirements for acceptance shall be replaced following the date of inspection and prior to November 30. Items specified for spring planting only shall be planted prior to the following April 30. Changes in the above dates will be allowed by the Engineer only if extreme weather conditions or other mitigating circumstances so dictate. When replacements are completed, the Contractor shall weed and thoroughly clean up the entire job to the satisfaction of the Engineer. Cleanup shall include pruning dead branches off the accepted plant material, spraying insect infected plants, removing staking and screening material, weeding, restoring mulch, removing work-related debris, and generally cleaning up the work site. When clean up operations have been completed, inspection will be made for replacement items only. All replacement items shall meet and be planted according to the original job specifications. Replacement plantings need not undergo a period of establishment to be accepted. However, replacement plants must be properly installed and in a live healthy condition at the time of inspection. Should

replacements include both spring and fall items, the Contractor may elect to plant all replacements in the spring, prior to May 15.

The Contractor shall remove, immediately from the site of the work, any dead plant material. During spring or fall planting, the Contractor will not be permitted to terminate the operation until all plant material is in a live, healthy condition. All plant material which dies within 15 days after being planted shall be replaced at that time and shall be considered as part of the original planting and be subject to the requirements of the period of establishment.

253.15 Plant Care. During the period of establishment, the Contractor shall properly care for all plants including weeding, watering, adjusting of braces, repair of water saucers, or other work which is necessary to maintain the health and satisfactory appearance of the plantings. All requirements for proper care during the period of establishment shall be considered as included in the cost of the contract and shall be performed within five days following notification by the Engineer.

- (a) During the period of establishment, additional watering shall be performed at least once within every 30 days during the months of May through December. The Engineer may direct the Contractor to adjust the watering rate and frequency depending upon weather conditions.

The water shall be applied to individual plants in such a manner that the plant hole shall be saturated without allowing the water to overflow beyond the earthen saucer. Watering of plants in beds shall be applied in such a manner that all plant holes are uniformly saturated without allowing the water to flow beyond the periphery of the bed. The plants to be watered and the method of application will be approved by the Engineer. The Contractor will not be relieved in any way from the responsibility for unsatisfactory plants due to the amount of watering.

- (b) During the period of establishment, weeds and grass growth shall be removed from within the earthen saucer of individual trees and from the area within the mulched plant beds. This weeding shall be performed twice during each of the months of May through September. The Contractor will not be relieved in any way from the responsibility for unsatisfactory plants due to the extent of weeding.

The weeding may be performed in any manner approved by the Engineer, provided the weed and grass growth, including their roots and stems, are removed from the area specified. Mulch disturbed by the weeding operation shall be replaced to its original condition. All debris which results from this operation must be removed from the right-of-way at the end of each day.

253.16 Method of Measurement. This work will be measured for final payment, in place, after the period of establishment. Trees, shrubs, and vines will be measured as each individual plant. Seedlings will be measured in units of 100 plants.

253.17 Basis of Payment. This work will be paid for at the contract unit price per each for TREES, SHRUBS, or VINES, of the species, root type, and plant size specified; and per unit for SEEDLINGS. Payment will be made according to the following schedule.

- (a) Initial Payment. Upon planting, 75 percent of the pay item(s) will be paid.
- (b) Final Payment. Upon inspection and acceptance of the plant material, or upon execution of a third party bond, the remaining 25 percent of the pay item(s) will be paid.

SECTION 254. PLANTING PERENNIAL PLANTS

254.01 Description. This work shall consist of furnishing, transporting, and planting perennial plants.

254.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Bulb Type	1081.02(a)
(b) Ornamental Type	1081.02(b)
(c) Prairie Type	1081.02(b)
(d) Wetland Emergent Type	1081.02(b)
(e) Sedge Meadow Type	1081.02(b)
(f) Woodland Type	1081.02(b)
(g) Mulch	1081.06(b)

254.03 Planting Time. Planting times for the various types of perennial plants shall be as follows.

- (a) Bulb Type. Bulb type plants shall be planted between October 15 and November 15.
- (b) Ornamental Type, Prairie Type, Wetland Emergent Type, and Sedge Meadow Type plants shall be planted between May 1 and June 15 or between August 15 and September 15.
- (c) Woodland Type plants shall be planted between April 1 and May 15.

254.04 Transporting and Storing Plants. The Engineer will inspect the plants at the work site at the beginning of each planting day and reject any material that is not properly packaged (including clear labeling by species) or that is not in a firm, moist, or viable condition. Any plants remaining at the end of the day shall be removed from the work site and properly stored by the Contractor. Before planting, sufficient water shall be added to potted plants to insure that the soil around the roots is not dry and crumbly when the plants are removed from the pots.

254.05 Layout of Planting. When plants are specified to be planted in prepared soil planting beds, the planting bed shall be approved by the Engineer prior to planting. If no prepared soil planting bed is specified, the plants shall be planted in areas that have existing cover or have been seeded and mulched or sodded. Where perennial plants, except bulb type plants, shall be planted, the planting beds shall be delineated with selective mowing stakes. Selective mowing stakes shall be according to Article 250.08.

254.06 Planting Procedures. The spacing of the plants shall be as shown on the plans, or as directed by the Engineer, to uniformly fill the planting beds. Individual plants within the beds shall be planted as follows.

- (a) Bulb Type. Bulb type plants shall be planted to a depth of 6 in. (150 mm) in turf areas or prepared beds.
- (b) Ornamental Type, Prairie Type, Wetland Emergent Type, Sedge Meadow Type, and Woodland Type. When planted in prepared soil planting beds, these plants shall be planted by a hand method approved by the Engineer.

When planted in existing turf, the planting area shall be mowed to a maximum height of 2 in. (50 mm).

In existing cover, or seeded and mulched or sodded planting areas, a 12 in. (300 mm) diameter planting area for individual plants shall be prepared. The existing cover, or seed and mulch shall be cut and removed from the 12 in. (300 mm) diameter planting area and the soil within the planting area loosened to a depth of 6 in. (150 mm). The plants shall be planted within the planting area and immediately watered with at least 1 gal (5 L) of water per plant.

254.07 Mulching. Within 24 hours, the plants shall be mulched with 2 in. (50 mm) of a fine grade mulch meeting the approval of the Engineer. Care shall be taken to place the mulch in a way that does not smother the plants. When plants are planted in prepared soil planting beds, the entire bed shall be mulched. Bulb type plants planted in existing turf need not be mulched.

254.08 Period of Establishment. Period of Establishment for the various types of perennial plants shall be as follows.

- (a) No period of establishment will be required for bulb type plants.
- (b) Perennial plants must undergo a 30 day period of establishment. Additional waterings shall be performed at least once within every seven days for four weeks following installation. Water shall be applied at the rate of 2 gal/sq yd (9 L/sq m). Should excess moisture prevail, the Engineer may delete any or all of the additional watering cycles. In severe weather, the Engineer may require additional waterings.

Watering of plants in beds shall be applied in such a manner that all plant holes are uniformly saturated without allowing the water to flow beyond the periphery of the bed.

At the end of the period of establishment, the Contractor will be permitted to replace any unacceptable plants and shall thoroughly weed all the beds.

254.09 Method of Measurement. This work will be measured for payment in units of 100 perennial plants of the type and size specified. Measurement for payment of this work will not be performed until at the end of the 30 day establishment period for the replacement planting. Only plants that are in place and alive at the time of measurement will be measured for payment, except that if fewer

than 25 percent of the plants are acceptable, a quantity equal to 25 percent of the number of units of plants originally planted will be considered measured for payment.

Selective mowing stakes will be measured for payment as each in place.

254.10 Basis of Payment. This work will be paid for at the contract unit price per unit for PERENNIAL PLANTS, of the type and size specified.

Selective mowing stakes will be paid for at the contract unit price per each for SELECTIVE MOWING STAKES.

TEMPORARY EROSION AND SEDIMENT CONTROL

SECTION 280. TEMPORARY EROSION AND SEDIMENT CONTROL

280.01 Description. This work shall consist of constructing, maintaining, removing, and disposing of temporary erosion control systems.

280.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Bale Stakes	1081.15(a)
(b) Fence Stakes	1081.15(b)
(c) Hay or Straw Bales	1081.15(c)
(d) Fence	1081.15(d)
(e) Aggregate	1081.15(e)
(f) Silt Filter Fence	1080.02
(g) Temporary Mulch Material	1081.06
(h) Rolled Excelsior	1081.15(f)
(i) Temporary Erosion Control Seeding.....	1081.15(g)
(j) Inlet Filters	1081.15(h)
(k) Filter Fabric	1080.03
(l) Urethane Foam/Geotextile	1081.15(i)

CONSTRUCTION REQUIREMENTS

280.03 General. The Contractor shall name a person at the preconstruction meeting who shall be on the jobsite during construction and who shall be responsible for ensuring the erosion control work is completed in a timely manner.

The Contractor and the Department shall schedule and conduct a jobsite inspection to review and designate the locations and types of erosion control systems to be placed. This inspection shall be conducted prior to beginning any work which will disturb existing drainage or require erosion control.

Erosion control systems shall be installed prior to beginning any activities which will potentially create erodible conditions. Erosion control systems for areas outside the limits of construction such as storage sites, plant sites, waste sites, haul roads, and Contractor furnished borrow sites shall be installed prior to beginning soil

disturbing activities at each area. These offsite systems shall be designed by the Contractor and be subject to the approval of the Engineer.

The temporary erosion and sediment control systems shown on the plans represent the minimum systems anticipated for the project. Conditions created by the Contractor's operations, or for the Contractor's convenience, which are not covered by the plans, shall be protected as directed by the Engineer at no additional cost to the Department. Revisions or modifications of the erosion and sediment control systems shall have the Engineer's written approval.

Work shall be coordinated such that no more than a total of 10 acres (4 hectares) are disturbed at a time. Completed slopes shall be seeded and mulched as the excavation proceeds to the extent considered desirable and practical. Permanent seeding shall be used whenever possible. Under no circumstances shall the Contractor prolong final grading and shaping so that the entire project can be permanently seeded at one time.

Temporary erosion control systems shall be coordinated with the permanent erosion control features to ensure economical, effective, and continuous erosion control. Work shall also be coordinated such that permanent erosion control features and seeding are not damaged; and repeated disturbances of temporary erosion control systems are kept to a minimum.

280.04 Temporary Erosion Control Systems. Temporary erosion control systems shall be constructed as shown on the plans and, where appropriate, according to the manufacturer's specifications. Specific requirements for the various types of systems shall be as follows.

- (a) Temporary Ditch Checks. This system consists of the construction of temporary ditch checks to prevent siltation, erosion, or scour of ditches and drainage ways. Temporary ditch checks shall be constructed with products from the Department's approved list, rolled excelsior, or with aggregate placed on filter fabric when specified. Filter fabric shall be installed according to the requirements of Section 282. Riprap shall be placed according to Article 281.04. Manufactured ditch checks shall be installed according to the manufacturer's specifications. Spacing of ditch checks shall be such that the low point in the center of one ditch check is at the same elevation as the base of the ditch check immediately upstream. Temporary ditch checks shall be sufficiently long enough that the top of the device in the middle of the ditch is 6 in. (150 mm) lower than the bottom of the terminating ends of the ditch side slopes.

When rolled excelsior is used, each ditch check shall be installed and maintained such that the device is no less than 10 in. (250 mm) high at the point of overflow. Units installed at a spacing requiring a height greater than 10 in. (250 mm) shall be maintained at the height for the spacing at which they were originally installed.

- (b) Perimeter Erosion Barrier. This system consists of a continuous barrier placed adjacent to an area of construction to intercept a sheet flow of water borne silt and sediment and prevent it from leaving the construction area.

The barrier shall be constructed with rolled excelsior, silt filter fence, or urethane foam/geotextiles.

- (c) Inlet and Pipe Protection. This system consists of surrounding inlets, pipe inlets or outfalls, and other similar locations as required to intercept water borne silt and sediment and prevent it from entering the drainage system or exiting the construction area. The protection shall be constructed with hay or straw bales, silt filter fence, or inlet filters.

When inlet filters are specified, they shall be installed either directly on the drainage structure or under the grate of the drainage structure resting on the lip of the frame. The fabric bag shall hang down into the drainage structure. Prior to ordering materials, the Contractor shall determine the size and shape of the various drainage structures being protected.

- (d) Sedimentation Basins. This system consists of excavating and maintaining temporary basins at pipe inlets or outfalls, in ditches, and in drainageways to capture water borne silt and prevent it from exiting the construction area. The outfall of these basins is usually protected by perimeter erosion barrier to capture remaining silt.
- (e) Temporary Ditches. This system consists of constructing temporary ditches to intercept water borne silt and runoff.
- (f) Temporary Erosion Control Seeding. This system consists of seeding all erodible/bare areas to minimize the amount of exposed surface area. Seed bed preparation will not be required if the soil is in a loose condition. Light disking shall be done if the soil is hard packed or caked. Fertilizer nutrients will not be required.

The original seed bags shall be opened in the presence of the Engineer. The seed shall be applied by hand broadcasting to achieve a reasonably uniform coverage at a rate of 100 lb/acre (110 kg/ha). Seed shall be applied to all bare areas every seven days, regardless of weather conditions or progress of the work. The Engineer may require that critical locations be seeded immediately and the Contractor shall seed these areas within 48 hours of such a directive.

- (g) Temporary Mulch. This system consists of installing temporary mulch cover over designated areas to prevent sheet erosion of areas that are to be altered during a later construction phase. The temporary mulch cover shall be installed according to Article 251.03 except for any reference to seeding.
- (h) Temporary Erosion Control Blanket. This system consists of temporarily installing erosion control blanket or heavy duty erosion control blanket over areas that are to be reworked during a later construction phase. Work shall be according to Article 251.04 except references to seeding and fertilizer shall not apply. When an area is to be reworked more than once, the blanket shall be carefully removed, properly stored, and then reinstalled over the same area.

280.05 Maintenance. The temporary erosion control systems shall be properly maintained as directed by the Engineer to control siltation. This work shall include repair of the various systems, removal of trapped sediment, and cleaning of any silt filter fabric. Accumulated silt in sediment basins shall be removed when the basin becomes 75 percent filled. Trapped sediment and accumulated silt shall be disposed of according to Article 202.03.

280.06 Disposal. All temporary erosion control systems shall be removed at the direction of the Engineer and be disposed of according to Article 202.03.

280.07 Method of Measurement. This work will be measured for payment according to the following.

- (a) Sediment Basins and Temporary Ditches. The earth excavation for sediment basins and temporary ditches will be measured for payment in place and the volume computed in cubic yards (cubic meters).

The aggregate used for sediment basins will be measured for payment in tons (metric tons).

- (b) Temporary Ditch Checks. This work will be measured for payment along the long axis of the device in place in feet (meters), except for aggregate ditch checks which will be measured for payment in tons (metric tons). Payment will not be made for aggregate in excess of 108 percent of the amount specified by the Engineer.
- (c) Perimeter Erosion Barrier. This work will be measured for payment in place in feet (meters).
- (d) Inlet and Pipe Protection. This work will be measured for payment as individual items and the unit of measurement will be each.
- (e) Temporary Erosion Control Seeding. This work will be measured for payment in pounds (kilograms) of seed applied.
- (f) Temporary Mulch. This work will be measured for payment according to Article 251.05(b).
- (g) Temporary Erosion Control Blanket. This work will be measured for payment in place in square yards (square meters) of actual surface covered.

Temporary erosion control measures and work ordered by the Engineer due to the Contractor's carelessness or failure to install permanent controls will not be measured for payment.

Temporary or permanent erosion control systems required for areas outside the limits of construction will not be measured for payment.

280.08 Basis of Payment. This work will be paid for according to the following.

- (a) Sediment Basins and Temporary Ditches. The earth excavation for sediment basins and temporary ditches will be paid for at the contract unit price per cubic yard (cubic meter) for EARTH EXCAVATION FOR EROSION CONTROL.

The aggregate used for sediment basins will be paid for at the contract unit price per ton (metric ton) for AGGREGATE (EROSION CONTROL).

- (b) Temporary Ditch Checks. This work will be paid for at the contract unit price per foot (meter) for TEMPORARY DITCH CHECKS, except for aggregate ditch checks which will be paid for at the contract unit price per ton (metric ton) for AGGREGATE DITCH CHECKS.
- (c) Perimeter Erosion Barrier. This work will be paid for at the contract unit price per foot (meter) for PERIMETER EROSION BARRIER.
- (d) Inlet and Pipe Protection. This work will be paid for at the contract unit price per each for INLET AND PIPE PROTECTION.

Protection of drainage structures with inlet filters will be paid for at the contract unit price per each for INLET FILTERS.

- (e) Temporary Erosion Control Seeding. This work will be paid for at the contract unit price per pound (kilogram) for TEMPORARY EROSION CONTROL SEEDING. When light disking of hard or caked soil is directed by the Engineer, it will be paid for according to Article 109.04.
- (f) Temporary Mulch. Temporary Mulch will be paid for according to Article 251.06.
- (g) Temporary Erosion Control Blanket. Temporary Erosion Control Blanket will be paid for at the contract unit price per square yard (square meter) for TEMPORARY EROSION CONTROL BLANKET or TEMPORARY HEAVY DUTY EROSION CONTROL BLANKET.

The work of removing, storing, and reinstalling the blanket over areas to be reworked more than once will not be paid for separately but shall be included in the cost of the temporary erosion control blanket or temporary heavy duty erosion control blanket.

SECTION 281. RIPRAP

281.01 Description. This work shall consist of furnishing and placing bedding material, a protective course of stone or broken concrete laid as riprap for erosion protection or sediment control.

281.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Stone	1005.01
(b) Broken Concrete	1005.02

CONSTRUCTION REQUIREMENTS

281.03 Preparation. The bed for the riprap shall be excavated to allow the finished surface to conform to the lines specified. At the toe of the slope, the riprap shall commence on a continuation of the slope after excavation to accommodate the full depth of fabric, bedding lift, and riprap specified.

281.04 Placing. No riprap shall be placed until the preparation has been approved by the Engineer.

Installation of filter fabric and bedding material will be required under stone riprap gradations RR 4, RR 5, RR 6, and RR 7 for all uses, and under broken concrete and stone, or broken concrete dumped riprap when used for erosion protection. The fabric shall be installed according to the plans and Section 282. The placement of material shall begin at the lower elevations, progressing up the slope.

- (a) Stone Riprap. Class A1 bedding material shall be used with riprap Classes A4, A5, B4, and B5. Class A2 bedding material shall be used with riprap Classes A6, A7, B6, and B7. When filter fabric is used, the following substitutions of bedding material may be made: Quality B may be used in lieu of Quality A; Gradation CA 3 may be used in lieu of Gradation RR 1; and Gradation CA 1 may be used in lieu of Gradation RR 2.

Bedding material shall be spread uniformly on the filter fabric to the lines specified. Placing of material by methods which will tend to segregate particle sizes within the bedding will not be permitted. Any damage to the surface of the bedding material or the filter fabric during placing of the bedding shall be repaired before proceeding with the work.

Compaction of the bedding material will not be required; but it shall be finished to present a reasonably even surface, free from mounds, windrows, or depressions.

The thickness of the stone riprap lift shall be according to the following table.

Gradation	Min. Thickness	Bedding Thickness
RR 1 & RR 2	6 in. (150 mm)	-
RR 3	8 in. (200 mm)	-
RR 4	16 in. (400 mm)	6 in. (150 mm)
RR 5	22 in. (550 mm)	8 in. (200 mm)
RR 6	26 in. (650 mm)	10 in. (250 mm)
RR 7	30 in. (750 mm)	12 in. (300 mm)

Stone riprap shall be placed to the lines and grades shown on the plans. All tapers between minimum thickness and any high points shall be at a uniform rate. There shall be no abrupt changes in the riprap surface.

The riprap shall be placed to its full course thickness in one operation and in such a manner as to avoid displacing the bedding material. The riprap shall not be placed or dropped from a height of more than 1 ft (300 mm). Placing riprap by dumping into chutes or by similar methods likely to cause segregation of the various sizes will not be permitted.

The finished riprap shall be reasonably well graded with a minimum of voids. The desired distribution of the various sizes of stones shall be obtained by selective loading of the material at the source, by controlled dumping of successive loads during final placing, or by other methods of placement which will produce the specified results. Rearranging of individual stones by mechanical equipment or by hand will be required to the extent necessary to obtain a reasonably well-graded distribution of stone sizes as specified above.

- (b) Broken Concrete Riprap. Bedding placement, when required, shall be as described for stone riprap in (a). The individual pieces of broken concrete shall be placed by hand, flat upon the slope. The pieces shall be laid with close joints, the larger pieces being placed in the lower courses. Any open joints shall be filled with spalls thoroughly rammed into place. The finished surface of the riprap shall present an even, close surface, true to the lines, grades and sections given.
- (c) Stone or Broken Concrete Dumped Riprap. Bedding placement, when required, shall be as described for stone riprap in (a). The dumped riprap shall be a minimum of 12 in. (300 mm) thick. Dumped riprap of stone or broken concrete, as specified, shall be placed on slopes or in channels by mechanical means. End dumping of material using mechanical equipment will be permitted, provided the larger stones or pieces of broken concrete are well-distributed and the entire mass, in final position, is roughly graded to conform to the gradation specified. Placement by dumping into chutes or other methods likely to cause segregation will not be permitted.

The finished riprap shall be reasonably free from objectionable pockets of small pieces and clumps of large pieces, and the surface shall be shaped to

follow the grade of the slope or channel. Rearranging of the dumped stone or broken concrete by mechanical equipment or by hand will be required only to the extent necessary to remove objectionable pockets or clumps of small or large material, and to obtain a surface reasonably true to line and grade.

281.05 Disposal of Surplus Material. Surplus or waste material shall be disposed of according to Article 202.03.

281.06 Method of Measurement. This work will be measured for payment in tons (metric tons); or measured in place, and the area computed in square yards (square meters). The area for measurement will include the upper sloped surface of the riprap and upper horizontal surface of the toe anchor.

Filter fabric will be measured for payment according to Article 282.08.

281.07 Basis of Payment. This work will be paid for at the contract unit price per square yard (square meter) or per ton (metric ton) for STONE RIPRAP or STONE DUMPED RIPRAP, of the class (stone quality and gradation) specified; BROKEN CONCRETE RIPRAP; or BROKEN CONCRETE DUMPED RIPRAP.

Filter fabric will be paid for according to Article 282.09.

SECTION 282. FILTER FABRIC

282.01 Description. This work shall consist of furnishing and installing geotechnical filter fabric on a prepared earth surface.

282.02 Materials. The filter fabric shall be according to Article 1080.03.

CONSTRUCTION REQUIREMENTS

282.03 General. The filter fabric shall be stored above the ground, inside and away from sunlight at temperatures less than 140 °F (60 °C), and protected from damage. The exposure of the filter fabric to the elements between laydown and cover shall be a maximum of 14 days.

282.04 Preparation. The depth and area of excavation shall not exceed the dimensions necessary to properly place the filter fabric. Prior to the installation of the fabric, the surface shall be cleared of debris, sharp objects, and trees. Tree stumps shall be cut to the level of the prepared ground surface. If stumps cannot be cut to the ground level, they shall be completely removed. All wheel tracks, ruts, or surface irregularities in excess of 2 in. (50 mm) in depth shall be graded smooth or otherwise filled with soil to provide a reasonably smooth surface. The filter fabric shall not be placed until the preparation has been approved by the Engineer.

282.05 Placement. At the time of placement, the fabric shall be free of defects, deterioration, and damage.

The fabric shall be unrolled directly over the surface either by hand or by mechanical methods, provided the surface is not rutted. The long dimension of the fabric shall be parallel to the centerline of the channel or shoreline. Overlaps in the fabric shall be placed so that any upstream strip of fabric will overlap the downstream strip, and the upslope roll shall overlap the downslope roll.

The fabric shall be laid loosely, free of folds and creases. The fabric shall be turned down and buried 2 ft (600 mm) at all exterior limits, except where a stone filled key trench is provided below natural ground. As the riprap proceeds up the grade, the top edge of the fabric shall be buried as a part of the last operation.

Fabric of insufficient width or length to fully cover the specified area shall be lapped or sewn. The minimum laps for lap only areas are 12 in. (300 mm) and for sewn areas are 4 in. (100 mm).

When sewn, the fabric shall be stitched at a minimum rate of four stitches per 1 in. (25 mm) with high-strength polyester, polypropylene, or kevlar thread. The seam strength shall be equal to or more than the minimum grab tensile strength of the fabric when tested wet according to ASTM D 4632.

282.06 Securing Pins. Securing pins for anchoring filter fabric shall be nominally 3/16 in. (5 mm) diameter steel bars, pointed at one end and fabricated with a head to retain a steel washer having an outside diameter of not less than 1 1/2 in. (40 mm). The length of the pin shall not be less than 12 in. (300 mm). Securing pins shall be inserted through both strips of overlapped cloth at not greater than the following intervals along a line through the midpoint of the overlap.

Slope	Pin Spacing
Steeper than 1:3 (V:H)	2 ft (600 mm)
1:3 (V:H) to 1:4 (V:H)	3 ft (900 mm)
Flatter than 1:4 (V:H)	5 ft (1.5 m)

Each securing pin shall be pushed through the fabric until the washer bears against the fabric and secures it firmly to the surface. Additional pins, regardless of location, shall be installed as necessary to prevent any slippage of the filter fabric. When the Engineer determines that the proper lap is not being maintained by the use of pins, the fabric shall be sewn according to Article 282.05.

282.07 Protection. The fabric shall be protected during construction from contamination by surface runoff, and any fabric so contaminated shall be removed and replaced.

Fabric damaged during its installation or during placement of riprap shall be replaced or repaired. Repairs shall be made by removing the material around the damage and covering it with a patch of fabric using an overlap of 4 ft (1.2 m) in each direction. The patch shall be held in position with securing pins.

282.08 Method of Measurement. This work will be measured for payment in place and the area computed in square yards (square meters). The buried edges of

Art. 282.08 Aggregate Ditch

the fabric will not be measured for payment and the overlap joints and seams will be measured as a single lift of material.

282.09 Basis of Payment. This work will be paid for at the contract unit price per square yard (square meter) for FILTER FABRIC.

SECTION 283. AGGREGATE DITCH

283.01 Description. This work shall consist of furnishing and installing aggregate in roadside ditches.

283.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Aggregate Ditch	1005.01
(b) Filter Fabric	1080.03

CONSTRUCTION REQUIREMENTS

283.03 Aggregate Ditch. The stone aggregate ditch shall be constructed on filter fabric without any bedding material.

The filter fabric shall be constructed according to Section 282, except that the edges along the centerline of the ditch shall be turned down and buried 6 in. (150 mm), the upstream and downstream edges shall be turned down and buried 12 in. (300 mm), and securing pins at overlaps shall be inserted at each edge of the ditch bottom and at intervals of not greater than 5 ft (1.5 m) extending up the slopes.

The aggregate lift shall be a minimum of 12 in. (300 mm) thick and placed to the lines and grades as shown on the plans, or as directed by the Engineer. The placement of the aggregate shall begin at the lower elevation and proceed up the slope in such manner to construct a reasonably well graded mass of stone free from objectionable pockets of small stones and clusters of large stones. Arranging of stones may be required to the extent necessary, either mechanically or by hand, to obtain a well graded distribution of stone sizes and grade lines. Disturbed soil surfaces not covered with stone aggregate shall be seeded, fertilized and mulched according to Sections 250 and 251.

283.04 Method of Measurement. Aggregate ditch will be measured for payment in tons (metric tons) according to Article 311.08(b).

Filter fabric will be measured for payment according to Article 282.08.

283.05 Basis of Payment. This work will be paid for at the contract unit price per ton (metric ton) for AGGREGATE DITCH.

Filter fabric will be paid for according to Article 282.09.

SECTION 284. GABIONS AND SLOPE MATTRESS

284.01 Description. This work shall consist of furnishing and placing a protective course of stone confined by wire baskets used as retaining walls, slope paving, bank protection, weirs, drop structures, or outfall structures.

284.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Stone for Erosion Control (Note 1)	1005.01
(b) Gabions and Slope Mattresses	1006.35
(c) Wire Fasteners	1006.36
(d) Anchor Stakes	1006.04, 1006.18
(e) Filter Fabric	1080.03

Note 1. The stone shall conform to the requirements of Quality Designation A and shall not contain objectionable quantities of dirt, sand, clay, or rock fines. The stone shall be well graded with maximum stone dimensions ranging between 4 to 8 in. (100 to 200 mm). No stone shall have a minimum dimension less than 3 in. (75 mm), and the ratio of maximum to minimum dimension shall not be greater than two.

CONSTRUCTION REQUIREMENTS

284.03 Fabricating Gabions and Slope Mattresses. Baskets shall be fabricated in such a manner that the sides, ends, lid, and diaphragms can be assembled at the construction site into rectangular baskets of the sizes specified and shown on the plans. Baskets furnished by the manufacturer shall be of uniform size. Baskets shall be of single unit construction, i.e., the base, lid, ends, and sides shall be either woven into a single unit or one edge of these members connected to the base section of the basket in such a manner that strength and flexibility at the point of connection is at least equal to that of the mesh. Where the length of the basket exceeds 1 1/2 its horizontal width, the basket shall be equally divided by diaphragms, of the same mesh and gauge as the body of the baskets, into cells whose length does not exceed the horizontal width. The basket shall be furnished with the necessary diaphragms secured in proper position on the base in such a manner that no additional tying at this juncture will be necessary. Baskets shall be assembled by tying or fastening all untied edges. The tying wire shall be tightly laced around every fabric opening along the seams in such a manner that single and double loops are alternated. If wire fasteners are used, they shall be installed at approximately 4 to 6 in. (100 to 150 mm) intervals, but not less than one fastener for each fabric opening along the joint.

Sufficient wire fasteners, lacing, and connecting wire to match the basket material shall be supplied with the baskets for all fastening operations carried out in the construction of the gabion and mattress work.

All perimeter edges of the baskets, including end panels and the diaphragms, if any, shall be mechanically selvaged in such a way as to prevent any unravelling of the fabric and to develop the full strength of the fabric. The wire used for the selvage shall have a diameter greater than that of the wire used to form the fabric.

284.04 Foundation Preparation. The bed for the gabions or slope mattress shall be trimmed and shaped to conform to the line and grade shown on the plans and as directed by the Engineer.

284.05 Placing. After the Engineer has approved the foundation preparation, a layer of filter fabric shall be installed. Installation of the filter fabric will be required under both the gabions and the slope mattress, and behind the gabions. The filter fabric shall be installed according to the plans.

The baskets shall be placed as shown on the plans. The stone material shall be placed in close contact in the unit so that maximum fill is obtained.

Empty basket units shall be assembled individually and placed on the approved surface to the lines and grades as shown on the plans or as directed by the Engineer, with the sides, ends, and diaphragms erected in such a manner to insure the correct position of all creases and that the tops of all sides are level. All adjoining empty gabion units shall be secured to the adjoining unit in order to obtain a monolithic structure. Wire fasteners may be used in lieu of lacing wire for forming individual baskets, joining empty baskets together and closing lids. Binding wire or wire fasteners shall be used along vertical reinforced edges and top selvages. When baskets are stacked, the base of the top basket shall be tightly wired or fastened to the lower basket at front and back. Lacing of adjoining basket units shall be accomplished by continuous stitching with alternating single and double loops at intervals of not more than 5 in. (125 mm). All lacing wire terminals shall be securely fastened. If wire fasteners are used, a fastener shall be provided at each fabric opening along the joint. A minimum of six fasteners are required per 3 ft (1 m) seam, three fasteners are required per 18 in. (450 mm) seam and two fasteners per 12 in. (300 mm) seam.

The initial line of basket units shall be placed on the prepared surface in a direction parallel to stream flow, and partially filled to provide anchorage against deformation and displacement during filling operations. After adjoining empty basket units are set to line and grade and common sides with adjacent units thoroughly laced or fastened, baskets shall be placed in tension and stretched to remove any kinks from the fabric and to a uniform alignment. The stretching of empty basket units shall be accomplished in such a manner as to prevent any possible unraveling.

Stone filling operations shall carefully proceed with placement by hand or machine so as not to damage the wire coating, to assure a minimum of voids between the stones, and the maintenance of alignment throughout the filling process. Undue deformation and bulging of the fabric shall be corrected prior to further stone filling. To avoid localized deformation, the basket units in any row are to be filled in stages consisting of maximum 12 in. (300 mm) courses. Baskets 18 in. (450 mm) tall or more shall use connecting wires in each internal compartment after each 9 or 12 in. (225 or 300 mm) lift, except when the lid is closed over the last lift. For baskets 18 in. (450 mm) tall, the connecting wires shall be installed between the 9 in. (225 mm) lifts of stone. The 3 ft (1 m) tall baskets shall have connecting wires installed between each 12 in. (300 mm) lift of stone. These wires shall connect the front face to the back face. All connecting wires shall be looped around two fabric openings and the ends of the wires securely twisted to prevent loosening. For end units, two

additional connecting wires shall be placed at each level perpendicular to the normally required connecting wires.

At no time shall any cell be filled to a depth exceeding 12 in. (300 mm) more than the adjoining cell. The maximum height from which the stone may be dropped into the basket units shall be 3 ft (1 m).

Along all exposed faces, the outer layer of stone shall be carefully placed and arranged by hand to insure a neat and compact appearance. The last layer of stone shall be leveled with the top of the gabion to allow for the proper closing of the lid and to provide an even surface that is uniform in appearance. Lids shall be stretched tight over the stone fill using only an approved lid closing tool, until the lid meets the perimeter edges of the front and end panels. Using crowbars or other single point leverage bars for lid closing shall be prohibited. The lid shall then be tightly tied with lacing wire along all edges, ends, and internal cell diaphragms by continuous stitching with alternating single and double loops at intervals not more than 5 in. (125 mm). Wire fasteners may be used in lieu of lacing wire. Special attention shall be given to see that a projections or wire ends are turned into the baskets. Where shown on the plans or as directed by the Engineer, or where a complete gabion unit cannot be installed because of space limitations, the basket unit shall be cut, folded, and wired together to suit existing site conditions. The fabric must be cleanly cut and the surplus fabric cut out completely, or folded back and neatly wired to an adjacent gabion face. The assembling, installation, filling, lid closing, and lacing of the reshaped gabion units shall be carried out as specified above.

The slope mattress shall be anchored as shown on the plans. If the Contractor elects to drill for the soil anchor stakes, care shall be taken to avoid drilling holes to a greater depth than is necessary to place the top of the finished stake slightly above the top of the finished mattress.

The Contractor may assemble, partially fill, and tie together mattress units on the subgrade, provided they can be placed on the slope without abrading the zinc or vinyl coating on the wire mattress or permanently distorting the shape of the mattress in transporting and installing the units on the slope. All prefabrication procedures shall be subject to the approval of the Engineer.

The Contractor shall maintain the gabions or slope mattress until final acceptance and any material displaced by any cause shall be replaced.

284.06 Disposal of Surplus Material. Surplus or waste material resulting from the gabion or slope mattress operations shall be disposed of according to Article 202.03.

284.07 Method of Measurement. Gabions will be measured for payment in place and the volume computed to the nearest cubic yard (cubic meter), based on the actual lengths, widths, and depths. Slope mattress will be measured for payment in place and the area computed in square yards (square meters) based on the actual lengths and widths over which placement is made.

Filter fabric will be measured for payment according to Article 282.08.

284.08 Basis of Payment. This work will be paid for at the contract unit price per cubic yard (cubic meter) for GABIONS or at the contract unit price per square yard (square meter) for SLOPE MATTRESS, of the thickness specified.

Filter Fabric will be paid for according to Article 282.09.

SECTION 285. CONCRETE REVETMENT MATS

285.01 Description. This work shall consist of constructing fabric formed concrete revetment mat; or furnishing and placing precast block revetment mat, and articulated block revetment mat.

285.02 Materials. Materials shall be according to the following.

(a) Fabric Formed Concrete Revetment Mat.

Item	Article/Section
(1) Grout	1024.01
(2) Fabric Formed Concrete Revetment Mats	1080.04

(b) Precast and Articulated Block Revetment Mats.

Item	Article/Section
(1) Precast Concrete Block (Note 1)	1042
(2) Cable, Anchors and Fittings (Note 2)	
(3) Portland Cement Concrete (Note 3)	1020

Note 1. The block size, block weight (mass), block configuration (interlocking or non-interlocking), and mat configuration (open-cell or closed-cell) shall be as specified on the plans.

Note 2. Cable, anchors, and fittings, such as sleeves, clamps, and stops, shall be according to the manufacturer's specifications and shall be corrosion resistant.

Note 3. Class SI concrete shall be used.

285.03 Equipment. Equipment shall be according to the following.

- (a) Fabric Formed Concrete Revetment Mat. Mixing and pumping equipment used in preparation and handling of the grout shall be approved by the Engineer. All oil or other rust inhibitors shall be removed from the mixing drums, stirring mechanisms, and other portions of the equipment in contact with the grout before the mixers are used. The pumping equipment shall have a variable flow rate to provide enough pressure for pumping without breaking the fabric.
- (b) Precast and Articulated Block Revetment Mats. Equipment used to lift and place the blocks/mats shall be approved by the Engineer.

CONSTRUCTION REQUIREMENTS

285.04 General. The surface to be protected shall be graded as shown on the plans and prepared such that it is stable in the absence of erosive forces. Any fill material required to restore the surface to its original condition shall be approved by the Engineer.

285.05 Fabric Formed Concrete Revetment Mat. The grout shall consist of a mixture of portland cement, fine aggregate, and water so proportioned and mixed as to provide a pumpable slurry. Fly ash and concrete admixtures may be used at the option of the Contractor. The grout shall have an air content of not less than 6.0 percent nor more than 9.0 percent of the volume of the grout. The mix shall obtain a compressive strength of 2500 psi (17,000 kPa) at 28 days according to Article 1020.09.

All materials shall be accurately measured by volume or weight (mass) as they are fed into the mixer. Time of mixing shall be not less than one minute. If agitated continuously, the grout may be held in the mixer or agitator for a period not exceeding two and one-half hours in temperatures below 70 °F (21 °C), and for a period not exceeding two hours at higher temperatures. If there is a lapse in a pumping operation, the grout shall be recirculated through the pump or through the mixer drum (or agitator) and pump.

Prior to grout injection, the fabric shall be positioned at its design location. Each panel shall be a continuous or monolithic unit for its full width, including the trench portion.

Each panel shall consist of two or more mill-widths of open selvage construction; the two upper layers shall be joined together by sewing, and the two bottom layers shall be sewn together at the edges. Where adjacent panels cannot be joined in this manner, they shall be lapped a minimum of 24 in. (600 mm). In no case will simple butt-joints, either sewn or unsewn, be permitted. The ends and upper limits of the fabric shall be placed in a trench of suitable width as shown on the plans.

Filling of the fabric shall begin at the lower elevations and proceed up the slope. The grout shall be injected between the layers of fabric through small cuts. The point of injection shall be a maximum of 30 ft (9 m) from the end of the panel. The grout shall be pumped without exerting excessive pressure on the fabric envelope.

After grouting has been completed, the void between the trench wall and filled fabric shall be backfilled. Injection holes left in the fabric shall be closed by temporarily inserting a piece of burlap or similar material. The burlap shall be removed when the grout is no longer fluid and the surface is firm to hand pressure. Foot traffic on the filled revetment mats shall be kept to an absolute minimum for one hour after pumping.

285.06 Precast Block Revetment Mat. Filter fabric shall be installed according to Section 282 prior to placement of the precast block revetment mat, or it may be secured to the bottom of the mat according to the manufacturer's specifications and installed concurrently.

The precast blocks may be placed individually or as pre-assembled mats. Normally, placement shall begin at the downstream end and proceed upstream. At side slopes, placement shall begin at the toe and proceed up. All edges of the precast block revetment mat shall be flush with the existing ground.

Orientation of the blocks with respect to water flow shall be as specified by the manufacturer.

After placement, the voids in and around the blocks shall be filled with soil meeting the approval of the Engineer.

285.07 Articulated Block Revetment Mat. Filter fabric shall be installed according to Section 282 prior to placing the articulated block revetment mat, or it may be secured to the bottom of the mat according to the manufacturer's specifications and installed concurrently.

Normally, placement of the mats shall begin at the downstream end and proceed upstream. At side slopes, placement shall begin at the toe and proceed up. The upstream and outside edges of the mat shall be trenched at least one block deep and backfilled. The downstream edge shall be flush with the existing ground.

As mats are placed, they shall be anchored at the frequency and depth shown on the plans. If required by the manufacturer, adjacent mats shall be clamped or crimped together as well.

After placement of the mats, the voids in and around the blocks shall be filled with soil meeting the approval of the Engineer.

Excessive openings between mats shall be filled, as directed by the Engineer, with concrete.

285.08 Disposal of Surplus Material. Surplus or waste material shall be disposed of according to Article 202.03. Excess excavated material shall not remain in the flood plain, nor shall it be placed within the banks of the waterway.

285.09 Method of Measurement. This work will be measured for payment in place and the area computed in square yards (square meters). The area for measurement will include the upper, sloped surface of the mat. The portion of the mat in trenches will not be measured for payment. No allowance will be made for overlaps.

Filter fabric will be measured for payment according to Article 282.08.

285.10 Basis of Payment. This work will be paid for at the contract unit price per square yard (square meter) for FABRIC FORMED CONCRETE REVETMENT MAT, PRECAST BLOCK REVETMENT MAT, or ARTICULATED BLOCK REVETMENT MAT.

Filter fabric will be paid for according to Article 282.09.

DIVISION 300. SUBGRADES, SUBBASES, AND BASE COURSES**SUBGRADE****SECTION 301. SUBGRADE PREPARATION**

301.01 Description. This work shall consist of preparing the completed or existing earthwork as an unimproved subgrade prior to constructing the pavement structure, shoulders, or appurtenances.

301.02 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Steel Wheel Roller	1101.01
(b) Tamping Roller	1101.01
(c) Pneumatic-Tired Roller	1101.01
(d) Subgrade Planer	1103.08
(e) Subgrade Machine	1103.09

CONSTRUCTION REQUIREMENTS

301.03 General. When the contract includes rough grading and surfacing, the rough grading shall be completed as far in advance of the construction of the surfacing as feasible.

When the rough grading has been included in a previous contract, all vegetation shall be removed prior to preparing the subgrade.

The subgrade shall be prepared such that after compaction, it will be smooth and conform to the alignment, grades, and cross sections shown on the plans.

Surplus excavated material resulting from grading and shaping the subgrade shall be disposed of according to Article 202.03. When additional material is required, it shall be obtained from within the right-of-way when possible and approved by the Engineer. Placement shall be according to Articles 205.04 and 205.05.

301.04 Subgrade Compaction and Stability. When compacted, the subgrade shall have a minimum dry density of 95 percent of the standard laboratory dry density and a minimum immediate bearing value (IBV) of 8.0. Densities will be determined according to Article 205.06. The IBV will be determined according to Illinois Test Procedure 501 or 502.

In cut sections, the Contractor shall take the following steps in an effort to obtain the required density and stability.

- (a) Step 1. Cut plan ditches, which drain the area, at least to grade. This shall be done at least two weeks prior to Step 2.

- (b) Step 2. Air dry the top 8 in. (200 mm) of subgrade. This procedure shall include at least two 8 in. (200 mm) deep processings utilizing disks or tillers each day for three consecutive good drying days.
- (c) Step 3. Recompect the layer processed in Step 2 to achieve the required density, or until at least nine passes of a roller which has demonstrated ability to obtain the density on adjacent earth work have been made.

When the above steps have been performed and the required density and stability still have not been attained, the Engineer will make a determination as to whether additional drying and recompaction will be needed or whether the ground and soil conditions warrant more extensive treatments. Soft and unstable material that will not compact when rolled or tamped, shall be removed and disposed of according to Article 202.03, and replaced with material approved by the Engineer according to Articles 205.04 and 205.05.

Where rolling of the subgrade is required, any areas which are inaccessible to a roller shall be compacted by either a mechanical or hand tamper meeting the approval of the Engineer.

Equipment of such weight, or used in such a way as to cause a rut in the finished subgrade of 1/2 in. (13 mm) or more in depth, shall be removed from the work or the rutting otherwise prevented.

The subgrade will be approved by the Engineer before construction of the pavement structure, shoulders, or appurtenances is started.

301.05 Aggregate Base Course and Aggregate Surface Course, Type A.

The subgrade shall be compacted by rolling with a steel wheel or pneumatic-tired roller. The rolling shall extend at least 12 in. (300 mm) beyond each edge of the proposed base course.

301.06 Aggregate Surface Course, Type B. The subgrade will not have to be rolled prior to placement of the aggregate surface course, Type B.

301.07 Hot-Mix Asphalt (HMA) Base Course and Pavement (Full-Depth) and Portland Cement Concrete Base Course and Pavement. The work shall be extended to at least 18 in. (450 mm) beyond each edge of the proposed base course or pavement. When a subbase is being placed under the base course or pavement, the work shall be extended to include the area being covered by the subbase material.

Prior to final shaping, the subgrade shall be compacted with a steel wheel or pneumatic-tired roller. Steel wheel rollers shall weigh from 6 to 10 tons (5.5 to 9 metric tons) total and from 200 to 325 lb/in. (35 to 57 N/mm) of roller width.

The subgrade shall be brought to true shape by means of a subgrade planer and/or subgrade machine according to the following.

- (a) Either the subgrade planer or the subgrade machine shall be used when:

- (1) Portland cement concrete pavement or base course is constructed on the subgrade or subbase using forms.
 - (2) HMA base course is constructed.
- (b) The subgrade machine shall be used when:
- (1) Portland cement concrete pavement or base course is constructed on the subgrade or subbase using the slip form method.
 - (2) Continuously reinforced portland cement concrete pavement is constructed on the subbase or subgrade.
 - (3) HMA pavement (full-depth) is constructed.

When portland cement concrete is being placed directly on the subgrade, the subgrade shall be moist, but not muddy, at the time of placing the concrete. If required by the Engineer, the prepared subgrade shall be saturated with water the previous night, or not less than six nor more than 20 hours prior to the placing of the concrete. If the subgrade subsequently becomes too dry, it shall be sprinkled again ahead of placing the concrete, in such a manner as not to form mud or puddles of water.

The Contractor shall have at all times a minimum of one day's production of subgrade prepared ahead of the location at which the base course or pavement is being placed.

301.08 Gutters, Curbs, and Combination Curb and Gutter. The subgrade shall be compacted and finished to a firm, smooth surface in a manner approved by the Engineer.

301.09 Drainage. The subgrade shall be kept drained during the construction of the pavement structure. If earth berms are deposited along the edge of the subgrade, provision shall be made for surface drainage by cutting lateral ditches through the berms.

301.10 Maintenance. The prepared subgrade shall be maintained in a smooth and compacted condition.

301.11 Method of Measurement. When the contract includes both grading and paving, this work will not be measured for payment.

When the contract includes paving on a pregraded section, this work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of contract quantities shall be according to Article 202.07(a).
- (b) Measured Quantities. Subgrade preparation will be measured for payment in units of 100 ft (30 m) in horizontal distances along baselines. No allowance will be made for variable width roadways. No allowance will be made for excavation for removal or placement of any material within 2 in.

(50 mm) of the grade and cross section shown on the plans or established by the Engineer.

301.12 Basis of Payment. When the contract includes paving on a pregraded section, this work will be paid for at the contract unit price per unit for SHAPING AND GRADING ROADWAY.

Excavation for the removal or placement of material outside the 2 in. (50 mm) tolerance specified in Article 301.11(b) will be paid for according to Article 109.04.

Additional drying and compaction beyond the three steps listed in Article 301.04 will be paid for according to Article 109.04.

Excavation and replacement of soft and unstable material, as specified in Article 301.04, will be classified and paid for according to Article 104.02.

SECTION 302. SOIL MODIFICATION

302.01 Description. This work shall consist of constructing a modified soil layer composed of soil, water, and a modifier.

302.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Type I Portland Cement	1001
(b) Type IS Portland Blast-Furnace Slag Cement	1001
(c) Water	1002
(d) Hydrated Lime	1012.01
(e) By-Product, Hydrated Lime	1012.02
(f) By-Product, Non-Hydrated Lime	1012.03
(g) Lime Slurry	1012.04
(h) Fly Ash	1010
(i) Soil for Soil Modification (Note 1)	1009.01
(j) Bituminous Materials (Note 2)	1032

Note 1. This soil requirement only applies when modifying with lime (slurry or dry).

Note 2. The bituminous materials used for curing shall be emulsified asphalt RS-2, CRS-2, HFE 90, or HFE 150; rapid curing liquid asphalt RC-70; or medium curing liquid asphalt MC-70 or MC-250.

302.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Distributor (Note 1)	
(b) Rotary Speed Mixer	1101.06
(c) Disk Harrow (Note 2)	1101.02
(d) Lime Slurry Equipment (Note 3)	

Note 1. The distributor shall be a mechanical type and shall be approved by the Engineer.

Note 2. A disk harrow may be used for soil modification with portland cement, slag-modified portland cement, or lime (slurry or dry) when permitted by the Engineer.

Note 3. The equipment used for mixing, transporting, slaking, and placing lime slurry shall be approved by the Engineer.

CONSTRUCTION REQUIREMENTS

302.04 General. The modified soil shall be constructed when the temperature of the soil, measured 6 in. (150 mm) below the surface is above 50 °F (10 °C) and the ambient air temperature in the shade is above 45 °F (7 °C).

The quantity of modified soil constructed shall be limited to that which can be covered by the full thickness of PCC pavement or HMA binder during the same construction season.

302.05 Proportioning. Proportioning shall be as follows.

- (a) Samples. Samples of the soil modifier(s) and the project soil(s) shall be obtained and submitted to the Engineer at least 45 days prior to the construction of the modified soil. Sample sizes shall be a minimum of 25 lb (11 kg) for the modifier(s) and 200 lb (90 kg) for the project soil(s).
- (b) Mix Design. The actual proportions of modifier, soil, and water will be determined by the Engineer prior to construction using the submitted samples. The Engineer reserves the right to make such adjustments in proportions as are considered necessary during the progress of the work.

In no case shall proportions or type of modifier be changed during the progress of the work without permission from the Engineer.

302.06 Preparation of Subgrade. The area to be processed shall be shaped to the proper grade and cross section. All vegetation and other objectionable material shall be removed from within the limits of modification. In cut or at grade sections, the subgrade shall be prepared according to Articles 301.03 and 301.04; except the minimum immediate bearing value (IBV) of the soil below the soil to be modified, shall be according to the Department's "Subgrade Stability Manual".

302.07 Application of Modifier. The modifier shall be applied uniformly on the soil. The application of modifier shall be limited to that amount which can be mixed with the soil within the same working day.

After application of dry modifiers, but before the addition of any water, the surface of the subgrade shall be lightly scarified or disked. When lime slurry is used, the surface of the subgrade shall be lightly scarified or disked prior to the application of the slurry.

Dry modifiers shall not be applied when wind conditions are such that blowing modifier becomes objectionable to adjacent property owners or creates a hazard to traffic on adjacent highways, as determined by the Engineer.

Lime slurry shall be applied within 30 days of preparing and mixing the slurry, and shall be thoroughly agitated prior to application.

Modifier which has been damaged by hydration due to rain prior to or during the mixing operations, or has been displaced by the Contractor's equipment or other traffic after application, shall be replaced.

302.08 Mixing. The modifier, soil, and water shall be thoroughly mixed. Mixing shall continue until a homogenous layer of the required thickness has been obtained and a minimum of 75 percent of the mixture is smaller than 1 in. (25 mm). The moisture content of the modified soil shall be above optimum moisture content with a maximum of three percent above optimum.

For soil modification with fly ash, more than one pass of the rotary speed mixer may be necessary to obtain a homogenous mixture. If more than one pass of the rotary speed mixer is required, the application of the fly ash shall be modified such that 25 percent of the specified fly ash quantity is applied and mixed with a down-cut motion as a preparation for the final pass of the rotary speed mixer. The remaining specified quantity of fly ash shall be applied prior to the final pass of the rotary speed mixer. Mixing shall continue until a minimum 75 percent of the mixture is smaller than 1 in. (25 mm).

302.09 Compaction. Compaction of soil modified with portland cement, slag-modified portland cement, or fly ash shall be completed no later than one hour after mixing begins.

Compaction of soil modified with hydrated lime or by-product non-hydrated lime shall be completed within the same day.

Compaction of soil modified with lime slurry shall begin within 24 hours.

Compaction of soil modified with by-product hydrated lime shall be delayed a minimum of 24 hours. The Engineer may require additional water or further mixing prior to the final compaction of soil modified with by-product hydrated lime. In no case shall compaction be started later than three days after mixing, unless approved by the Engineer. If compaction is to be delayed, the surface of the soil shall be crown-graded and sealed from moisture loss by either blade dragging or light rolling immediately after mixing.

The compacted, modified soil shall have a minimum dry density of 95 percent of the laboratory standard dry density. The in-place dry density will be determined according to AASHTO T 191, or Illinois Modified AASHTO T 310 (Direct Transmission Density/Backscatter Moisture). The laboratory standard dry density will be determined according to AASHTO T 99.

302.10 Finishing and Curing. When multiple lifts are used to construct the modified soil layer, the top lift shall be a minimum of 6 in. (150 mm) thick when compacted.

Construction of pipe underdrains shall follow the requirements of Article 407.07. The surface of the modified soil shall be kept drained according to Article 301.09 and shall maintain moisture content not exceeding three percent above optimum prior to pavement construction.

When compaction of the modified soil is nearing completion, the surface shall be shaped to the required lines, grades, and cross section shown on the plans. For HMA base course and pavement (full-depth) and portland cement concrete base course and pavement, the surface of the modified soil shall be brought to true shape and correct elevation according to Article 301.07, except well compacted earth shall not be used to fill low areas.

The modified soil shall be cured for a minimum of 24 hours. The ambient air temperature shall be above 45 °F (7 °C) during curing.

During the curing period, the moisture content of the modified soil shall be maintained at optimum by sprinkling with water, use of plastic sheeting, or applying bituminous materials according to Article 312.14. During this period, no equipment or traffic will be permitted on the completed work beyond that required for maintenance of curing.

Equipment of such weight, or used in such a way as to cause a rut depth of 1/2 in. (13 mm) or more in the finished modified soil, shall be removed, or the rutting otherwise prevented, as directed by the Engineer.

302.11 Subgrade Stability. Following curing, the Engineer will determine the stability of the modified soil in terms of the immediate bearing value (IBV), according to Illinois Test Procedure 501. The IBV shall be a minimum of 10.0 measured within 10 calendar days prior to pavement construction.

No equipment or traffic shall be on the modified soil after compaction until the required IBV is attained.

302.12 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Processing modified soils will be measured for payment in place and the area computed in square yards (square meters). The width for measurement will be as shown on the plans.

Modifier will be measured for payment in tons (metric tons). The modifier will be measured in trucks or freight cars. The Contractor shall furnish or arrange for use of scales of a type approved by the Engineer. When the modifier is shipped in trucks, it will be measured at the place of loading, at the place of unloading, or at such other place as the Engineer may designate. The Engineer may accept original signed freight bills in lieu of determining the weight (mass).

Should the Contractor's method of construction require extra earth excavation or embankment due to requiring more than one lift to construct the modified soil layer as shown on the plans, this extra earth excavation and embankment will not be measured for payment.

302.13 Basis of Payment. This work will be paid for at the contract unit price per square yard (square meter) for PROCESSING MODIFIED SOIL, of the thickness specified and per ton (metric ton) for LIME, FLY ASH, PORTLAND CEMENT, or SLAG-MODIFIED PORTLAND CEMENT.

SUBBASE

SECTION 310. LIME STABILIZED SOIL MIXTURE

310.01 Description. This work shall consist of the construction of a lime stabilized soil mixture, composed of soil, lime, and water which shall be considered as subbase.

310.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Water	1002
(b) Hydrated Lime	1012.01
(c) By-Product, Non-Hydrated Lime	1012.03
(d) Lime Slurry	1012.04
(e) Soil for Lime Stabilization	1009.02
(f) Bituminous Materials (Note 1)	1032

Note 1. The bituminous materials used for curing shall be emulsified asphalt RS-2, CRS-2, HFE 90, or HFE 150; rapid curing liquid asphalt RC-70; or medium curing liquid asphalt MC-70 or MC-250.

310.03 Equipment. Equipment shall be according to Article 302.03, except a disk harrow may be used when permitted by the Engineer.

CONSTRUCTION REQUIREMENTS

310.04 General. The lime stabilized soil mixture shall be constructed when the temperature of the soil measured 6 in. (150 mm) below the surface is above 50 °F (10 °C) and the ambient air temperature in the shade is above 45 °F (7 °C).

The quantity of lime stabilized soil mixture constructed shall be limited to that which can be covered by the full thickness of PCC pavement or HMA binder during the same construction season.

310.05 Proportioning. Proportioning shall be as follows.

- (a) Samples. Samples of the lime and the project soil(s) shall be obtained and submitted to the Engineer at least 45 days prior to the construction of the

lime stabilized soil mixture. Sample sizes shall be a minimum of 25 lb (11 kg) for the lime and 200 lb (90 kg) for the project soil(s).

- (b) **Mix Design.** The actual proportions of lime, soil, and water will be determined by the Engineer prior to construction using the submitted samples. The Engineer reserves the right to make such adjustments in proportions as are considered necessary during the progress of the work.

In no case shall proportions or type of lime be changed during the progress of the work without permission from the Engineer.

310.06 Preparation of Subgrade. The area to be processed shall be shaped to the proper grade and cross section. All vegetation and other objectionable material shall be removed from within the limits of lime treatment. In cut or at grade sections, the subgrade shall be prepared according to Articles 301.03 and 301.04; except the minimum immediate bearing value (IBV) of the soil below the soil to be stabilized, shall be 3.0.

310.07 Application of Lime. The lime (slurry or dry) shall be applied uniformly on the soil. The application of lime shall be limited to that area where the initial mixing operations can be completed during the same working day.

After application of dry lime, but before the addition of any water, the surface of the subgrade shall be lightly scarified or disked. When lime slurry is used, the surface of the subgrade shall be lightly scarified or disked prior to the application of the slurry.

Dry lime shall not be applied when wind conditions are such that blowing lime becomes objectionable to adjacent property owners or creates a hazard to traffic on adjacent highways, as determined by the Engineer.

Lime slurry shall be applied within 30 days of preparing and mixing the slurry, and shall be thoroughly agitated prior to application.

Lime (slurry or dry) that has been exposed to the open air for a period of six hours or more shall be replaced. Lime (slurry or dry) which has been damaged by hydration due to rain prior to or during the mixing operations, or has been displaced by the Contractor's equipment or other traffic after application, shall be replaced.

310.08 Mixing. Mixing shall be performed in two stages as follows.

- (a) **Initial Mixing.** The lime, soil, and water shall be thoroughly mixed until a uniform mixture throughout the required depth and width is obtained. All clods and lumps shall be reduced to a maximum size of 2 in. (50 mm). The moisture content of the stabilized soil shall be above optimum moisture content with a maximum of three percent above optimum.

After mixing, the surface shall be sealed with a light rolling. The mixture shall then be left to undergo a conditioning period of at least 48 hours. The mixture shall be maintained in a moist condition throughout the entire conditioning period.

- (b) **Final Mixing.** After the required conditioning period, the mixture shall be uniformly mixed and maintained at approximately optimum moisture content. If the mixture contains clods, they shall be pulverized to meet the following requirements.

Sieve Size	Minimum % Passing
1 in. (25 mm)	100
No. 4 (4.75 mm)	60

Mixing may be performed in a single stage when permitted by the Engineer, provided that the final mixing requirements are met.

310.09 Compaction. After final mixing, compaction shall be completed within the same day.

The compacted, lime stabilized soil mixture shall have a minimum dry density of 95 percent of the laboratory standard dry density. The in-place dry density will be determined according to AASHTO T 191, or Illinois Modified AASHTO T 310 (Direct Transmission Density/Backscatter Moisture). The laboratory standard dry density will be determined according to AASHTO T 99.

310.10 Finishing and Curing. When compaction of the lime stabilized soil mixture is nearing completion, the surface shall be shaped to the required lines, grades, and cross section shown on the plans. For HMA base course and pavement (full-depth) and portland cement concrete base course and pavement, the surface of the lime stabilized soil mixture shall be brought to true shape and correct elevation according to Article 301.07, except that well compacted earth shall not be used to fill low areas. The surface shall be maintained in a moist condition by means of a fine spray during all finishing operations.

Construction of pipe underdrains shall follow the requirements of Article 407.07. The surface of the lime stabilized soil shall be kept drained according to Article 301.09 and shall maintain a maximum moisture content of three percent above optimum prior to pavement construction.

The lime stabilized soil mixture shall be cured for a period of seven days and maintained at optimum moisture content by sprinkling with water or applying bituminous materials according to Article 312.14. During this period, no equipment or traffic will be permitted on the completed work beyond that required for maintenance of curing.

310.11 Subgrade Stability. Following curing, the Engineer will determine the stability of the lime stabilized soil mixture in terms of the immediate bearing value (IBV) according to Illinois Test Procedure 501. The IBV shall be a minimum of 23.0 measured within 10 calendar days prior to pavement construction.

No equipment or traffic shall be on the lime stabilized soil mixture after compaction until the required IBV is attained.

310.12 Construction Joints. Construction joints will not be required between each day's work, unless there is a time lapse of seven days or more between the

processing of adjacent sections. When construction joints are required, they shall be formed by cutting back 3 ft (1 m) into the completed work to form a vertical face. Otherwise, damage to completed work shall be avoided.

310.13 Maintenance. The lime stabilized soil mixture shall be maintained in a manner satisfactory to the Engineer. Maintenance shall include immediate repairs of any defective or damaged portions.

310.14 Method of Measurement. This work will be measured for payment as follows.

- (a) **Contract Quantities.** The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) **Measured Quantities.** Processing lime stabilized soil mixture will be measured for payment in place and the area computed in square yards (square meters). The width of measurement will be as shown on the plans.

Lime will be measured for payment in tons (metric tons). The lime will be measured in trucks or freight cars. The Contractor shall furnish or arrange for use of scales of a type approved by the Engineer. When the lime is shipped in trucks, it will be measured at the place of loading, at the place of unloading, or at such other place as the Engineer may designate. The Engineer may accept original signed freight bills in lieu of determining the weight (mass).

Should the Contractor's method of construction require additional earth excavation or embankment due to requiring more than one lift to construct the lime stabilized soil mixture as shown on the plans, this extra earth excavation and embankment will not be measured for payment.

310.15 Basis of Payment. This work will be paid for at the contract unit price per square yard (square meter) for PROCESSING LIME STABILIZED SOIL MIXTURE, of the thickness specified; and per ton (metric ton) for LIME.

SECTION 311. GRANULAR SUBBASE

311.01 Description. This work shall consist of furnishing, placing, and compacting granular material on the prepared subgrade as shown on the plans.

311.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate	1004.04

311.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Steel Wheel Rollers	1101.01(e)
(b) Pneumatic-Tired Rollers	1101.01
(c) Vibratory Machine (Note 1)	
(d) Subgrade Planer	1103.08
(e) Subgrade Machine	1103.09

Note 1. The vibratory machine shall meet the approval of the Engineer.

CONSTRUCTION REQUIREMENTS

311.04 Subgrade. The subgrade shall be prepared according to Section 301, except Articles 301.05 and 301.06 will not apply.

311.05 Placing and Compacting Subbase Materials. The granular material shall be placed and compacted as specified for the particular type of granular subbase. If any earth is worked into the granular material during the compacting or finishing operations, all granular material within the affected area shall be removed and replaced with new granular material. The Engineer may restrict hauling over the completed or partially completed work after inclement weather or at any time when the earth subgrade is soft and there is a tendency for the earth to work into the granular material.

The granular material shall be placed and compacted at least three days prior to the placement of pavement or base course. Except where required for temporary access, the quantity of subbase granular material Types A or B to be placed shall be limited to that which can be covered by the full thickness of PCC pavement or HMA binder during the same construction season.

If the moisture content is insufficient to maintain satisfactory compaction or to prevent segregation or raveling when hauling is permitted over the granular material, water shall be added as directed by the Engineer.

When construction of the granular subbase has been completed at a location, or when directed by the Engineer, the Contractor shall salvage the excess granular material outside the construction limits of the granular subbase. The salvaged granular material shall be carried forward and utilized in the construction of the granular subbase. The Contractor shall salvage the granular material in such a manner as to prevent segregation and the incorporation of earth.

Placing and compacting of the different subbase granular material types shall be as follows.

- (a) Subbase Granular Material, Type A. The granular material shall be uniform in gradation. Before the material is deposited on the roadway, it shall contain the amount of moisture required for compaction. The amount of moisture required shall be that determined by the Engineer for the material and the compaction methods being used. The water and granular material

shall be mixed through a controlled aggregate mixing system. The system shall consist of a mechanical mixing device and aggregate and water measuring devices meeting the approval of the Engineer. Wetting the aggregate by jetting in cars, bins, stockpiles, or trucks will not be permitted. Moisture shall be added to the material during compaction only when it is necessary to increase the percentage of moisture to obtain satisfactory compaction.

The subbase shall be constructed in lifts not more than 4 in. (100 mm) thick when compacted, except that if tests indicate that the desired results are being obtained, the compacted thickness of any lift may be increased to a maximum of 8 in. (200 mm).

The granular material shall be deposited full-lane width with a mechanical spreader or spreader box of a type approved by the Engineer, in a manner that shall not cause segregation and that shall require minimum blading or manipulation. The equipment and the method used shall be approved by the Engineer.

Each lift shall be compacted immediately after placing. The granular material shall be compacted to not less than 95 percent of the standard laboratory density.

The standard laboratory density shall be the maximum dry density determined according to AASHTO T 99 (Method C). A coarse particle correction according to AASHTO T 224 shall be used.

The dry density of the compacted subbase will be determined by the Engineer at regular intervals according to AASHTO T 191, Illinois Modified AASHTO T 310 (Direct Transmission Density/Backscatter Moisture), or by other methods approved by the Engineer.

- (b) Subbase Granular Material, Type B. The subbase shall be constructed in lifts not more than 6 in. (150 mm) thick when compacted, except that if tests indicate that the desired results are being obtained, the compacted thickness of any lift may be increased to a maximum of 8 in. (200 mm). Each lift of material shall be compacted in a manner approved by the Engineer. If the moisture content of the material is such that compaction satisfactory to the Engineer cannot be obtained, sufficient water shall be added so that satisfactory compaction can be obtained.
- (c) Subbase Granular Material, Type C. The subbase shall be compacted to the satisfaction of the Engineer. The manner of placing and compacting the material shall be approved by the Engineer prior to starting this work.

311.06 Finishing of Subbase for Base Course and Pavement. The subbase shall be brought to true shape according to Article 301.07, except for the following.

The compacted subbase shall be placed above the plan elevation and the excess trimmed or cut with the subgrade machine. The Contractor shall determine the amount of excess subbase material necessary to meet this requirement.

After the subbase has been brought to its true shape and correct elevation, the surface shall be wetted and rolled as directed by the Engineer with a steel wheel roller meeting the weight requirements specified in Article 301.07. The surface of the subbase shall then be tested for crown and elevation.

The Contractor shall have at all times a minimum of one day's production of subbase prepared ahead of the paving.

When portland cement concrete base course or pavement is being placed, the subbase shall be moist at the time of placement. If required by the Engineer, the prepared subbase shall be saturated with water the previous night, or not less than six nor more than 20 hours prior to the placing of the concrete. If the subbase subsequently becomes too dry, it shall be sprinkled again ahead of placing the concrete, in such a manner as not to form puddles of water.

311.07 Tolerance in Thickness. The subbase shall be constructed to the thickness shown on the plans. Thickness determinations shall be made at such points as the Engineer may select. When the constructed thickness is less than 90 percent of the thickness shown on the plans, aggregate shall be added to obtain the specified thickness; however, the surface elevation of the completed subbase shall not exceed by more than 3/16 in. (5 mm) the surface elevation shown on the plans or authorized by the Engineer.

311.08 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Granular subbase will be measured for payment in tons (metric tons), cubic yards (cubic meters), or square yards (square meters).

When the unit of measurement for the aggregate is tons (metric tons), the aggregate may be weighed in trucks or freight cars. The Contractor shall furnish or arrange for the use of scales of a type approved by the Engineer. If, at the time the Type A aggregate is weighed, it contains more than six percent of absorbed and free moisture by weight, a deduction for the amount of moisture in excess of this amount will be made in determining the pay quantity. Any aggregate that has been stockpiled will be weighed at the time it is incorporated into the work.

If the material is shipped in trucks, it may be weighed at the place of loading, at the place of unloading, or at such other place as the Engineer may designate. If the material is shipped in freight cars, the Engineer will accept the freight car weights, instead of scale weights, provided the Engineer is satisfied that the car weights are sufficiently accurate. In order to verify the car weights, the Contractor will be required to weigh the contents of at least ten percent of the freight cars received each day, with a minimum of one car weight each day, over truck scales. If the truck weights do not verify the freight car weights, additional cars shall be weighed. In addition to this

verification, the Contractor will be required to weigh the contents of any freight car that appears deficient in material. The Contractor shall furnish the original signed freight bill for each car.

When the unit of measurement for the aggregate is tons (metric tons), payment will not be made for aggregate in excess of 108 percent of the amount specified by the Engineer nor for aggregate placed outside the design width plus 6 in. (150 mm).

When the unit of measurement for the aggregate is cubic yards (cubic meters), the aggregate will be measured in place and the volume computed in cubic yards (cubic meters). The width and depth for measurement will be as shown on the plans.

When the unit of measurement for the aggregate is square yards (square meters), the aggregate will be measured in place and the area computed in square yards (square meters). The width for measurement will be as shown on the plans.

If the granular material removed during the subgrading operation is not carried forward and incorporated in the granular subbase, a deduction will be made for the quantity not salvaged, except that no deduction will be made where the quantity not salvaged is less than 2 cu yd/station (5 cu m/100 m) or where cubic yards (cubic meters) or square yards (square meters) is the basis of payment.

311.09 Basis of Payment. Subbase Granular Material, Type A, Subbase Granular Material, Type B, and Subbase Granular Material, Type C will be paid for at the contract unit price per ton (metric ton) for SUBBASE GRANULAR MATERIAL, TYPE A, SUBBASE GRANULAR MATERIAL, TYPE B, or SUBBASE GRANULAR MATERIAL, TYPE C; at the contract unit price per cubic yard (cubic meter) for SUBBASE GRANULAR MATERIAL, TYPE A, SUBBASE GRANULAR MATERIAL, TYPE B or SUBBASE GRANULAR MATERIAL, TYPE C; or at the contract unit price per square yard (square meter) of the thickness specified for SUBBASE GRANULAR MATERIAL, TYPE A, SUBBASE GRANULAR MATERIAL, TYPE B, or SUBBASE GRANULAR MATERIAL, TYPE C.

SECTION 312. STABILIZED SUBBASE

312.01 Description. This work shall consist of furnishing, placing, and compacting hot-mix asphalt (HMA), cement aggregate mixture, or pozzolanic stabilized mixture on the subgrade.

312.02 General. The Contractor shall have the option within the time limitations and weather condition requirements of selecting the type of stabilization, except no change in type will be permitted unless authorized by the Engineer. When time limitations or weather conditions require that construction of a particular type of stabilization be discontinued, the Contractor shall proceed without delay with the construction of an alternate type which is permissible under the requirements of this Section. The Contractor will receive no additional compensation by reason of such change.

Art. 312.02

Stabilized Subbase

Stabilized subbase shall not be placed on frozen or muddy subgrade.

The amount of stabilized subbase constructed will be limited to that which can be surfaced during the current construction season.

The Contractor shall have at all times one day's production of subbase prepared ahead of the paving location.

Prior to placing the stabilized mixture, the subgrade shall be prepared according to Section 301, except Articles 301.05 and 301.06 will not apply, or according to Section 302 when soil modification is used.

HOT-MIX ASPHALT

312.03 Materials. Materials shall be according to Section 1030.

312.04 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Steel Wheel Rollers (Note 1)	1101.01(e)
(b) Self-Propelled Pneumatic-Tired Roller (Note 2)	1101.01
(c) Vibratory Roller	1101.01
(d) Spreading and Finishing Machine (Note 3)	1102.03
(e) Trench Roller (Note 4)	1101.01
(f) Subgrade Machine	1103.09

- Note 1. Steel rollers shall weigh not less than 6 tons (5.5 metric tons) nor more than 12 tons (11 metric tons), and shall have a compression on the drive wheels of not less than 190 lb/in. (33 N/mm) nor more than 400 lb/in. (70 N/mm) of width of roller.
- Note 2. The self-propelled pneumatic-tired roller shall develop a compression of not less than 300 lb/in. (53 N/mm) of width of tire tread in contact with the hot-mix asphalt (HMA) surface.
- Note 3. Subbase in miscellaneous areas, too small to accommodate the spreading and finishing machine, may be placed with a mechanical spreader approved by the Engineer.
- Note 4. Trench rollers shall be self-propelled and shall develop a compression of not less than 300 lb/in. (53 N/mm) nor more than 400 lb/in. (70 N/mm) of width on the compaction wheel.

CONSTRUCTION REQUIREMENTS

312.05 Placing and Compacting. After the subgrade has been compacted and is acceptable to the Engineer, the HMA shall be placed with a spreading and finishing machine. The maximum compacted thickness of each lift shall be 6 in. (150 mm), provided the required density is obtained. The minimum compacted thickness of each lift shall be according to the following.

Nominal Maximum Aggregate Size of Mixture	Minimum Compacted Lift Thickness
CA 12 – 1/2 in. (12.5 mm)	1 1/2 in. (38 mm)
CA 10 – 3/4 in. (19 mm)	2 1/4 in. (57 mm)
CA 6 – 1 in. (25 mm)	3 in. (75 mm)

The surface of each lift shall be clean and dry before succeeding lifts are placed.

Immediately after each lift is placed, it shall be compacted with a vibratory roller and another roller.

The density of the compacted HMA shall be according to Article 1030.05(d)(3), (d)(4), and (d)(7).

The HMA mixture shall be delivered at a temperature of 250 to 350 °F (120 to 175 °C).

Any areas of the subbase which have been damaged shall be repaired by the Contractor to the satisfaction of the Engineer.

312.06 Finishing. The compacted subbase shall be placed above the plan elevation and the excess trimmed or cut with the subgrade machine. The Contractor shall determine the amount of excess subbase material necessary to meet this requirement.

CEMENT AGGREGATE MIXTURE

312.07 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement (Note 1)	1001
(b) Water	1002
(c) Coarse Aggregate (Note 2)	1004.04
(d) Bituminous Materials (Note 3)	1032.07 – 1032.09

Note 1. Only Type I or Type IA portland cement shall be used. Bulk cement may be used provided the equipment for handling the cement is approved by the Engineer.

Note 2. The aggregate shall be according to the following gradation requirements as determined according to Illinois Modified AASHTO T 27/T 11.

Sieve	Percent Passing
Passing 1 in. (25.0 mm) sieve	100 %
Passing 1/2 in. (12.5 mm) sieve	60 – 100 %
Passing No. 4 (4.75 mm) sieve	55 – 75 %
Passing No. 8 (2.36 mm) sieve	40 – 65 %
Passing No. 200 (75 µm) sieve	5 – 15 %

When blending is approved, fine material will be permitted in the blend, provided that the fine aggregate is Class C quality or higher and the mineral filler complies with the requirements of Article 1011.01. Blending proportions shall not be changed during the progress of the work without permission from the Engineer.

Note 3. The bituminous material used as a protective cover shall be emulsified asphalt RS-2, CRS-2, HFE 60, HFE 90, or HFE 150; rapid curing liquid asphalt RC-70; or medium curing liquid asphalt MC-70 or MC-250.

312.08 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Steel Wheel Rollers (Note 1)	1101.01(e)
(b) Tamping Rollers (Note 2)	1101.01
(c) Pneumatic-Tired Rollers	1101.01
(d) Trench Roller (Note 3)	1101.01
(e) Vibratory Roller	1101.01
(f) Subgrade Planer	1103.08
(g) Subgrade Machine	1103.09
(h) Cement Aggregate Mixture Equipment	1104.01

Note 1. Steel wheel rollers shall weigh from 6 to 12 tons (5.5 to 11 metric tons) and shall have a compression on the drive wheels of not less than 190 lb/in. (33 N/mm) nor more than 400 lb/in. (70 N/mm) of width of roller.

Note 2. In addition to the requirements of Article 1101.01, the tampers shall be long enough to penetrate within 1 in. (25 mm) of the prepared subgrade on the initial rolling.

Note 3. Trench rollers shall be self-propelled and shall develop a compression of not less than 300 lb/in. (53 N/mm) nor more than 400 lb/in. (70 N/mm) of width on the compaction wheel.

CONSTRUCTION REQUIREMENTS

312.09 General. The cement aggregate mixture (CAM) shall be placed only when the air temperature in the shade is above 40 °F (4 °C).

312.10 Composition. The Contractor shall submit to the Engineer a minimum of 25 lb (11 kg) of cement and 150 lb (70 kg) of aggregate which the Contractor proposes to use in the mixture at least 60 days prior to the construction of the stabilized subbase. Samples of the materials shall be taken under the supervision of the Engineer. The quantity of portland cement to be added to the aggregate shall be not less than five nor more than eight percent of the oven dry weight (mass) of the aggregate. The actual proportions of cement, water, and aggregate material will be set by the Engineer, according to the Department's Geotechnical Manual procedure, before work begins. The proportions will be based on tests conducted on mixtures composed of the samples of the constituent materials furnished by the Contractor. The cement content will be determined in the laboratory according to AASHTO T 135

and AASHTO T 136 and shall be such that the loss in weight (mass) will not be more than ten percent after 12 cycles of wetting and drying and freezing and thawing.

312.11 Mixing. The constituents of the mixture shall be accurately proportioned and thoroughly mixed in a mechanical mixer. The control of the mixture shall be of such accuracy that the quantity of cement shall be within ± 0.3 percent of the amount set by the Engineer.

The measuring devices for proportioning the mixture, either by volume or by weight, shall be of such accuracy that the proportions of the mixture will be maintained within the tolerances set forth in this Specification. The equipment used must be provided with means, meeting with approval of the Engineer, for calibration and check tests of the measuring devices.

In all plants, the water shall be proportioned by weight or volume and there shall be means by which the Engineer may readily verify the amount of water per batch or the rate of flow for continuous mixing.

The Contractor shall provide a platform scale and make arrangements for the use of a certified truck scale of sufficient capacity for calibration and periodic check tests of the feeders or measuring devices as needed during the production.

The mixer shall be capable of producing a uniform mixture. Mixing operations shall be continued until all ingredients are distributed evenly throughout the mixture and a uniform mixture, free of segregation, satisfactory to the Engineer, is obtained. The mixer shall be capable of discharging the mixture without undue segregation.

The moisture content at the time of mixing shall be such that the moisture content at the time of compaction will be within 80 to 110 percent of the optimum moisture determined.

312.12 Placing and Compacting. The construction requirements for subbase granular material, Type A, as stipulated in Section 311 shall apply to the construction of the CAM, except as stated. References to granular material in Section 311 shall be construed to include CAM.

The CAM shall be spread for the full width of the subbase.

Depositing and spreading operations shall be conducted so that the total time elapsing from the time water is added to the mixture until compaction is started will be less than 60 minutes. The compaction operations must be started within 30 minutes from the time the material is deposited on the subgrade.

The type, size, number of compactors, and the rate of their operations, shall be such that the section being processed will be fully compacted within two hours of the time that the water is added to the mixture.

If, for any reason, construction operations are delayed or suspended and the Engineer orders any loose or uncompacted material removed and disposed of, this work shall be performed at no additional cost to the Department.

The CAM may be constructed in one lift. If the density requirement cannot be complied with by placement in a single lift, then the mixture shall be constructed in two approximately equal lifts. The first lift shall be maintained in a moistened condition by means of a fine spray until the succeeding lift is placed. Just prior to placing the second lift, the upper 1/2 in. (13 mm) of the existing lift shall be scarified.

The dry density of the full depth of each compacted lift shall be 100 percent of the standard dry density as determined according to AASHTO T 134 (Method B) on the field mixture, unless the Contractor requests a variance of the first day's CAM placement.

The Department may consider a variance to approve the Contractor's request to establish a mix and procedures, providing that the following conditions are agreed to before starting work.

- (a) The mix shall consist of aggregate conforming to the requirement for CAM and seven percent cement.
- (b) A minimum compaction of 98 percent will be accepted, provided adjustments in mix or procedures are implemented to achieve a final compaction of 100 percent before the end of the day.
- (c) No variance will be permitted after the first day's placement and 100 percent compaction will be required for all subsequent work.
- (d) If the compaction does not comply with this requirement, the condition shall be corrected or the material replaced to conform to the specifications.

The density will be determined for compliance with these specifications by the Engineer according to AASHTO T 191, Illinois Modified AASHTO T 310 (Direct Transmission Density/Backscatter Moisture), or by other methods approved by the Engineer.

The CAM within the section being processed shall be constructed the full width and depth and the surface shall be trimmed and finished within a single working day.

No CAM may be salvaged.

312.13 Finishing. When initial compaction of the top lift of the CAM is nearing completion, the surface shall be shaped to the required lines, grades, and cross section according to the requirements of Article 311.06, and compaction continued until uniform and adequate compaction is attained. The moisture content of the surface material shall be maintained by means of a fine spray at or slightly above its optimum during all finishing operations and until the curing material is applied.

312.14 Protection and Cover. After the CAM has been finished, it shall be protected against drying for a period of seven days by applying a bituminous material. The bituminous material shall be applied as soon as possible after the completion of finishing operations, but in no event shall the finished CAM remain without cover for more than 24 hours. The equipment used for wetting the finished CAM with water or

to apply a bituminous protective cover shall be of such limited weight that its use will not cause marring or rutting of the subbase.

The bituminous material shall be applied at the rate of approximately 0.20 gal/sq yd (1 L/sq m) uniformly to the surface of the subbase by a pressure distributor to give complete coverage without excessive runoff. The exact rate of application and temperature will be specified by the Engineer. At the time the bituminous material is applied, the surface shall be tightly knit, free of all loose or extraneous material, and shall contain sufficient moisture to prevent penetration of the bituminous material. If needed, water shall be applied to fill the surface voids immediately before the bituminous cover is applied. Should it be necessary for construction equipment or other traffic to use the bituminous covered CAM before the bituminous material has hardened sufficiently to prevent pickup, sufficient sand shall be applied to prevent pickup.

Any finished or completed portion of the subbase which is traveled by construction equipment, or by other traffic, shall be protected in such a manner as to prevent the equipment or other traffic from marring or damaging the completed work.

At any time when the air temperature may be expected to reach the freezing point during the protection period, the subbase shall be protected from freezing with not less than 6 in. (150 mm) of loose, dry straw for seven days after placement or until the CAM has hardened.

After the seven day protection period, the straw shall be removed and disposed of according to Article 202.03.

312.15 Construction Joints. At the end of each day's construction, or when construction operations are delayed or suspended and the Engineer so orders, a straight transverse construction joint shall be formed by cutting back into the completed work to form a vertical face. Damage to completed work shall be avoided.

POZZOLANIC STABILIZED MIXTURE

312.16 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Water	1002
(b) Coarse Aggregate (Note 1)	1004.04
(c) Hydrated Lime	1012.01
(d) Portland Cement (Note 2)	1001
(e) Fly Ash	1010
(f) Water Reducing Admixture (Note 3)	1021
(g) Sand Cover	1003.01(a), 1003.01(e)
(h) Bituminous Materials (Note 4)	1032.07 – 1032.09

Note 1. The gradation requirements as determined according to Illinois Modified AASHTO T 27 / T 11 shall be as follows.

Sieve	Percent Passing
Passing 1 1/2 in. (37.5 mm) sieve	100 %
Passing 1 in. (25 mm) sieve	90 – 100 %
Passing 1/2 in. (12.5 mm) sieve	60 – 100 %
Passing No. 4 (4.75 mm) sieve	40 – 70 %
Passing No. 40 (425 µm) sieve	0 – 25 %
Passing No. 200 (75 µm) sieve (gravel)	0 – 10 %
(crushed stone and slag)	0 – 15 %

Alternate gradations will be considered, provided mixture design data is furnished to the Department for analysis. Specialized durability testing may be required for unique aggregate gradations or proposed combinations of materials for which the Department does not have historical performance data. Production gradation tolerances shall be as stated in Articles 1003.01 and 1004.01. The coarse or fine aggregate gradation which most nearly resembles the proposed gradation will be utilized for production tolerances.

Boiler Slag. In addition to the aggregates permitted in Article 1004.04, boiler slag may be used. The slag shall be wet-bottom boiler slag produced as a by-product of a power plant burning pulverized bituminous coal. The slag shall be composed of hard durable particles and shall be free of excessive or harmful amounts of foreign substances. Boiler slag in an oven dry condition shall conform to the following gradation requirements.

Sieve	Percent Passing
Passing No. 4 (4.75 mm) sieve	80 – 100 %
Passing No. 10 (2.00 mm) sieve	55 – 90 %
Passing No. 40 (425 µm) sieve	0 – 25 %
Passing No. 200 (75 µm) sieve	0 – 10 %

Note 2. Only Type I or Type IA shall be used.

Note 3. A water reducing admixture may be used if permitted by the Engineer. No adjustments will be made in the required lime or cement and pozzolan contents for this addition.

Note 4. The bituminous material used for curing shall be emulsified asphalt RS-2, CRS-2, HFE 90, or HFE 150; rapid curing liquid asphalt RC-70; or medium curing liquid asphalt MC-70 or MC-250.

The Contractor shall submit to the Engineer a minimum of 25 lb (11 kg) of lime or cement, 50 lb (25 kg) of fly ash, and 100 lb (50 kg) of the aggregate which the Contractor proposes to use in the mixture. The lime, when sampled, shall immediately be placed in a sealed container and shall be kept sealed. Samples shall be furnished at least 60 days prior to the construction of the subbase. The submitted samples will be tested for individual acceptance, for making design mixes, and for determining a tentative placement cut-off date.

312.17 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Steel Wheel Rollers (Note 1)	1101.01(e)
(b) Tamping Rollers (Note 2)	1101.01
(c) Pneumatic-Tired Rollers	1101.01
(d) Trench Roller (Note 3)	1101.01
(e) Vibratory Roller	1101.01
(f) Pozzolanic Aggregate Mixture Equipment	1104.01
(g) Mechanical Spreader (Note 4)	
(h) Wheel Saw (Note 5)	
(i) Subgrade Planer.....	1103.08
(j) Subgrade Machine.....	1103.09

Note 1. Steel wheel rollers shall weigh from 6 to 12 tons (5.5 to 11 metric tons) and shall have a compression on the drive wheels of not less than 190 lb/in. (33 N/mm) nor more than 400 lb/in. (70 N/mm) of width of roller.

Note 2. In addition to the requirements of Article 1101.01, the tampers shall be long enough to penetrate within 1 in. (25 mm) of the prepared subgrade on the initial rolling.

Note 3. Trench rollers shall be self-propelled and shall develop a compression of not less than 300 lb/in. (53 N/mm) nor more than 400 lb/in. (70 N/mm) of width on the compaction wheel.

Note 4. The mechanical spreader shall be self-propelled and equipped with an automatic screed and grade sensing controls which control the longitudinal grade and transverse slope of the screed. Screed controls shall be such that compensation for differences from the established slope and grade will be completely automatic. The screed shall be adjustable to produce the required cross section.

Note 5. The saw shall be capable of cutting the required joints to the width and depth shown on the plans, perpendicular to the pavement surface, and without excessive spalling or raveling.

CONSTRUCTION REQUIREMENTS

312.18 General. The activator for pozzolanic stabilized mixtures shall either be cement or lime at the option of the Contractor and the mixture shall be constructed between April 15 and October 15, except when lime fly ash is used, the transition date indicated in Table A will apply. Mixtures shall only be constructed when the air temperature in the shade is above 40 °F (4 °C).

The Contractor shall request, in writing, specific mixture design modifications for extension of the October 15 or transition dates in Table A. Samples of ingredient materials and request for verification shall be submitted to the Engineer by September 15 for cement activator and by August 15 for lime activator. Approval will be based on consideration of the cured strength development characteristics as determined by the Department's Geotechnical Manual procedure and the predicted

curing degree days. The Department may extend the construction season beyond the transition dates indicated for lime fly ash mixture. In no case shall cement fly ash subbase be constructed after November 7 in the Northern Zone (Districts 1 - 4) and after November 15 in the Southern Zone (Districts 5 - 9).

The amount of pozzolanic stabilized mixture constructed shall be limited to that which can be surfaced during the current construction season. The Contractor shall assure the Department that sufficient quantities of inspected ingredient material are available to complete the work.

TABLE A TRANSITION DATES FOR POZZOLANIC STABILIZED MIXTURE		
Required Compressive Strength, psi (kPa) ^{4/} (14 Day Cure @ 22 °C)		
Transition Date ^{1/}	Northern Zone ^{2/}	Southern Zone ^{3/}
Sept. 15	700 (4,800)	650 (4,500)
Oct. 1	850 (5,800)	700 (4,800)
Oct. 15	950 (6,500)	850 (5,800)

1/ The transition date must be verified by samples, representing July production, submitted to the Department by August 15 for testing.

2/ Districts 1, 2, 3, 4.

3/ Districts 5, 6, 7, 8, 9.

4/ According to AASHTO T 22, with no correction for the length-to-diameter ratio.

312.19 Composition. The cement or lime, pozzolan, and aggregate shall be proportioned within the following approximate limits on a dry weight basis.

APPROXIMATE PERCENT BY WEIGHT OF OVEN DRY AGGREGATE		
Ingredient	Gravel, Crushed Stone, Crushed Slag, or Aggregate Blend	Boiler Slag
Cement	3 to 5	3 to 6
Lime	3.5 to 6	3.5 to 6
Pozzolan	9 to 20	18 to 40
Aggregate	74 to 88.5	54 to 79.5

The actual proportions of lime or cement, pozzolan, water, and aggregate will be set by the Engineer before work begins. The actual proportions will be based on tests conducted on sample mixtures of the constituent materials furnished by the Contractor. The Department's Geotechnical Manual procedure will be utilized. The composition of the mixture will be such that when molded into cylinders (as prescribed in the Department's Geotechnical Manual procedure) and cured at 72 °F ± 2 °F (22 °C ± 1 °C) (14 day cure), the cylinders will have a minimum average compressive strength of 600 psi (4,100 kPa) according to AASHTO T 22 with no correction for the length-to-diameter ratio; with no individual test below 500 psi (3,400 kPa). The right is reserved by the Engineer to make changes in proportions during the progress of the work as the Engineer may consider necessary.

312.20 Mixing. Mixing shall be accomplished according to Article 312.11, except the control of the mixture shall be of such accuracy that the proportions of the mixture based on total dry weight will be maintained within the following tolerances.

Cement/Lime	± 0.5 percent by weight
Pozzolan	± 1.5 percent by weight
Aggregate	± 2.0 percent by weight

If a water reducing admixture is used, the automatic dispensing system shall be capable of continuously introducing the desired quantity of admixture within the range of ± 0.03 gal/min (± 0.11 L/min).

When constructing a cement/lime or pozzolan stabilized subbase, mixing and spreading operations shall be coordinated such that not more than 90 minutes shall elapse from the time water is added to the mixture and compaction operations begin.

312.21 Placing, Compacting, and Finishing. The mixture shall be placed on subgrade conforming to the requirements of Section 301. The Contractor shall have, at all times, at least 800 ft (240 m) of subgrade prepared in advance of the subbase placement. The pozzolanic stabilized mixture shall be constructed in lifts not more than 4 in. (100 mm) thick when compacted. If tests indicate that the desired results are being obtained, the compacted thickness of any lift may be increased to a maximum of 8 in. (200 mm) for lime fly ash and 12 in. (300 mm) for cement fly ash. When the thickness specified is more than maximum thickness, the mixture shall be placed in two or more approximately equal lifts. Each lift shall be deposited full width directly on the prepared subgrade or on the preceding lift of compacted mixture with a mechanical spreader or spreader box of a type approved by the Engineer. Where the mixture must be placed in more than one lift, the previous lift shall be maintained in a moistened condition until the succeeding lift is placed. After having been tested for density and approved by the Engineer, the previous lift shall be dampened with water, if required by the Engineer. The second lift shall be placed the same day as the first lift. When placed, the pozzolanic stabilized mixture shall be free from segregation and shall require minimum blading and manipulation.

Particular care shall be exercised to ensure satisfactory density along the edges of the section and adjacent to construction joints. The type, size, number of compactors, and the rate of their operation shall be such that the section being processed will be fully compacted within three hours of the time water is added to the mixture. The first lift of the subbase shall be compacted to at least 97 percent of maximum density. The succeeding lifts of subbase shall be compacted to 100 percent of maximum density. The maximum density will be determined according to AASHTO T 180, Method C, except that the five lift requirement is replaced with three lifts.

The density of each lift of the compacted subbase will be determined by the Engineer for compliance with these Specifications according to AASHTO T 191, Illinois Modified AASHTO T 310 (Direct Transmission Density/Backscatter Moisture), or by other methods approved by the Engineer. If these tests indicate that the lift does not comply with the density requirements, the condition shall be corrected or the material replaced to conform to these Specifications.

In constructing the top lift, the grade shall be kept at sufficient height so that the top surface, when compacted, will be at or slightly above grade, rather than below grade. Finish grading shall be accomplished by removing excess material followed by recompaction by rolling. In the event that low areas occur, they shall be reconstructed to the satisfaction of the Engineer.

If any subgrade material is worked into the pozzolanic stabilized mixture during the compacting or finishing operations, all pozzolanic mixture within the affected area shall be removed and replaced with new material. Any finished or completed portion of the subbase which is traveled by construction equipment, or by other traffic, shall be protected in such a manner as to prevent the equipment or other traffic from marring or damaging the completed work. The Engineer may restrict hauling over partially completed work or uncured subbase after inclement weather or at any time when the subgrade is soft and there is a tendency for the subgrade material to work into the pozzolanic stabilized mixture.

When initial compaction of the mixture is nearing completion, the surface of the subbase shall be shaped to the required lines, grades, and cross section. The moisture content of the surface of the subbase mixture shall be maintained at or slightly above its specified optimum during all finishing operations and until the curing material is applied.

Surface compaction and finishing shall be done in such a manner as to produce a smooth, closely knit surface, relatively free from cracks, ridges, low spots, or loose material. The finished surface shall be tested for crown and elevation by means of a template and shall meet the tolerance in thickness requirement as stated herein.

If for any reason construction operations are delayed or suspended and the Engineer orders any loose or uncompacted material removed and disposed of, this work shall be performed at no additional cost to the Department. No pozzolanic stabilized mixture may be salvaged.

312.22 Curing. After the pozzolanic stabilized mixture has been constructed, the surface shall be kept continuously moist until the bituminous curing cover is applied. The bituminous curing cover shall be applied no later than 24 hours following final compaction, unless in the judgment of the Engineer it should be delayed. The application of the curing cover shall be according to Article 312.14.

Paving may proceed after the curing cover has been applied and cured to the satisfaction of the Engineer. At least 14 hours for lime fly ash and 12 hours for cement fly ash shall elapse between the time the curing cover material is applied and paving begins.

312.23 Construction Joints and Maintenance. At the end of each day's construction, a straight transverse construction joint shall be formed by cutting back into the completed work to form a vertical face. If the cement fly ash subbase paving operations are discontinued for more than 24 hours or when the mixture has taken a set prior to the achievement of acceptable compaction, a longitudinal and/or transverse saw joint shall be cut and the material in the affected area shall be removed and disposed of according to Article 202.03. Damage to completed work shall be avoided.

In areas where irregular width, inaccessibility, or unavoidable obstacles make the use of mechanical spreading equipment impractical, such equipment will not be required, and the Contractor may use other methods approved by the Engineer. If full-width placement is impractical, placing the adjacent pass(es) with the specified mechanical spreader to achieve the desired pavement width must be completed the same day as placement of the first pass.

The Contractor shall maintain the entire subbase in a manner satisfactory to the Engineer until the pavement has been completed. Maintenance shall include immediate repairs of any defective or damaged portions of the subbase. Repairs or replacements shall be made in such a manner as to ensure restoration of a uniform surface and durability of the portion repaired or replaced. The Contractor shall also remove and replace full-depth any pozzolanic aggregate mixture which is unsatisfactory due to its being placed over excessively wet or otherwise unstable subgrade; damaged by rain, freezing or other climatic conditions; damaged by traffic; or which is unsatisfactory due to failure to comply with any of the requirements specified.

CEMENT AGGREGATE MIXTURE II

312.24 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate (Note 1)	1004.01-1004.02
(b) Fine Aggregate (Note 2)	1003.01-1003.02
(c) Portland Cement	1001
(d) Water	1002
(e) Concrete Curing Materials (Note 3)	1022
(f) Emulsified Asphalts (Note 4)	1032.06
(g) Concrete Admixtures	1021
(h) Fly Ash	1010

Note 1. Coarse aggregate shall be gradation CA 6, CA 7, CA 9, CA 10, or CA 11, Class D quality or better.

Note 2. Fine aggregate shall be FA 1 or FA 2.

Note 3. Membrane Curing Compound shall be Type III.

Note 4. RS-2 or CRS-2 shall be used.

312.25 Equipment. Equipment shall be according to Article 420.03.

CONSTRUCTION REQUIREMENTS

312.26 Proportioning. At least 60 days prior to start of placing CAM II, the Contractor shall submit samples of materials for proportioning and testing. The mixture shall contain a minimum of 200 lb (90 kg) of cement per cubic yard (cubic meter). For Type I cement, a maximum of 15 percent of cement may be replaced by fly ash at a 1:1.5 cement-to-fly ash ratio (weight basis). Blends of coarse and fine

aggregates will be permitted, provided the volume of fine aggregate does not exceed the volume of coarse aggregate. The Engineer will determine the proportions of materials for the mixture.

Air-entraining admixture and water-reducing admixture shall be added. Water-reducing admixtures shall be added to the mixer separately from air-entraining admixtures according to the manufacturer's printed instructions. The air-entrainment agent and the other admixture(s) shall be compatible. The water and air content of freshly mixed air-entrained CAM II shall be based upon trial mixes with the materials to be used in the work adjusted to produce a mixture of the required plasticity, workability, and durability. The mixture shall have a relative durability of 80 percent at 100 cycles when tested according to Illinois Modified AASHTO T 161 Procedure B. The percentage of air-entrainment shall not be less than seven percent nor more than ten percent. Air content shall be determined according to Article 1020.08. The mix shall have a slump of 1 to 3 in. (25 to 75 mm). Slump shall be determined according to Article 1020.07.

312.27 Mixing and Placing. CAM II shall be mixed according to Article 1020.11(c). CAM II shall be placed when the air temperature in the shade is a minimum of 40 °F (4 °C). Forms and form setting shall be according to Article 420.06 or as approved by the Engineer. The use of a mechanical form tamper will not be required. When a slipform paver will be used for placing the portland cement concrete or continuously reinforced portland cement concrete pavement, the CAM II subbase shall be constructed to a width 6 in. (150 mm) wider than the width outside-to-outside of the slipform paver's tracks. When this results in a width greater than shown on the plans or typical section, such extended width will not be measured for payment but shall be included in the unit price bid for the CAM II subbase. Placing CAM II shall be according to the requirements of Article 420.07, except that a mechanical concrete spreader will not be required. Vibratory screeds will be permitted. Slipform paving methods may be used, provided the requirements of Article 420.14(c) are met.

312.28 Finishing and Testing. After the CAM II subbase has been struck off and consolidated, and while it is still plastic, the surface including the paver trackline shall not have variations of more than 3/16 in. (5 mm) in 10 ft (3 m) measured parallel with the centerline of pavement. Any depressions shall immediately be filled with fresh CAM II mix, struck off, consolidated and refinished. Bumps shall be cut off and the area refinished. The finished surface shall not be textured, but shall be closed.

CAM II samples shall be furnished by the Contractor and shall be taken from unconsolidated material on grade to determine the slump and air content. Testing shall be according to Article 1020.07 and 1020.08.

312.29 Curing. Immediately after the finishing operations have been completed, the surface shall be cured and protected according to Articles 1020.13(a)(4), 1020.13(c) and 1101.09. All areas of membrane curing compound damaged by rain or other cause within the required three day curing period shall be repaired by applying another coat. Membrane curing compound damaged after the three-day curing period shall be repaired by reapplying membrane curing compound or by applying emulsified asphalt applied at the approximate rate of 0.20 gal/sq yd (1 L/sq m) to the surface with a pressure distributor according to the requirements of Article 1102.05.

312.30 Protection. Minor construction traffic will not be permitted on the completed subbase for at least three days, and no batch or haul trucks will be permitted on the completed subbase unless approved by the Engineer. Any CAM II mixture which is unsatisfactory due to rain, freezing, or other climatic conditions; damaged by traffic; or which is unsatisfactory due to failure to comply with any of the requirements specified shall be removed and replaced.

STABILIZED SUBBASE – ALL TYPES

312.31 Tolerance in Thickness. The stabilized subbase shall be constructed to the thickness shown on the plans. Determination of thickness will be based on measurements taken at cored holes or at the edge of the subbase.

When the constructed thickness is less than 90 percent of the specified thickness, the stabilized subbase shall be corrected. The method of correction shall be removal and replacement, except as follows.

- (a) HMA Stabilized Subbase. When HMA stabilized subbase is used, the deficient thickness may be corrected by placing additional HMA, provided the lift thickness requirements of Article 312.05 are met.
- (b) Portland Cement Concrete Pavement. When portland cement concrete pavement is to be constructed, the deficient thickness may be corrected by increasing the thickness of the pavement. This method of correction will not be allowed for continuously reinforced concrete pavement.

The surface elevation of the completed stabilized subbase, shall not exceed by more than 3/16 in. (5 mm) the surface elevation shown on the plans or authorized by the Engineer.

312.32 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. This work will be measured for payment in place and the area computed in square yards (square meters). The width measured will be at the top of the final lift of the completed work as shown on the plans or as directed by the Engineer.

312.33 Basis of Payment. When the Contractor has the option of which material type to use, this work will be paid for at the contract unit price per square yard (square meter) for STABILIZED SUBBASE of the thickness specified.

When the Department requires a specific material type be used, this work will be paid for at the contract unit price per square yard (square meter) for STABILIZED SUBBASE – HMA, STABILIZED SUBBASE – CAM, STABILIZED SUBBASE – POZZOLANIC, or STABILIZED SUBBASE – CAM II of the thickness specified.

BASE COURSE

SECTION 350. LIME STABILIZED SOIL MIXTURE

350.01 Description. This work shall consist of the construction of a lime stabilized soil mixture composed of soil, lime, and water which shall be considered as base course.

This work shall be according to Section 310, except the lime stabilized soil mixture shall provide a minimum laboratory average compressive strength of 150 psi (1030 kPa), according to AASHTO T 208.

350.02 Method of Measurement. This work will be measured for payment according to Article 310.14.

350.03 Basis of Payment. This work will be paid for according to Article 310.15.

SECTION 351. AGGREGATE BASE COURSE

351.01 Description. The base course shall consist of furnishing one or more courses of aggregate on a prepared subgrade or subbase.

351.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate	1004.04

351.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Tamping Rollers	1101.01
(b) Pneumatic-Tired Rollers	1101.01
(c) Steel Wheel Rollers (Note 1)	1101.01(e)
(d) Aggregate Spreaders	1102.04
(e) Vibratory Machine (Note 2)	

Note 1. Three-wheel or tandem rollers shall weigh from 6 to 10 tons (5.5 to 9 metric tons) and shall weigh not less than 200 lb/in. (35 N/mm) nor more than 325 lb/in. (57 N/mm) of width of the roller.

Note 2. The vibratory machine shall meet the approval of the Engineer.

CONSTRUCTION REQUIREMENTS

351.04 Subgrade. The subgrade shall be prepared according to Section 301, except Articles 301.06 and 301.07 will not apply.

351.05 Base Course. The aggregate shall be uniform in gradation. Wetting the aggregate in cars, bins, stockpiles, or trucks will not be permitted.

The base course shall be constructed in lifts not more than 4 in. (100 mm) thick when compacted, except that if tests indicate that the desired results are being obtained, the compacted thickness of any lift may be increased to a maximum of 8 in. (200 mm). The aggregate shall be deposited full-lane width, directly on the prepared subgrade or on the preceding lift of compacted aggregate with a spreader. When placed, it shall be free from segregation and shall require minimum blading or manipulation. Immediately after the material has been placed, it shall be compacted with a tamping roller, or with a pneumatic-tired roller, or with a vibratory machine, or with a combination of any of the three. The top lift shall be given a final rolling with a steel wheel roller. The manner of compaction shall be approved by the Engineer.

If any subgrade material is worked into the base material during the compacting or finishing operations, all granular material within the affected area shall be removed and replaced with new aggregate. The Engineer may restrict hauling over the completed or partially completed work after inclement weather or at any time when the subgrade is soft and there is a tendency for the subgrade material to work into the base material.

Specific requirements for Type A and Type B aggregate base course shall be as follows.

- (a) Type A. The aggregate shall have a bearing ratio of not less than 80, except that if the aggregate used is crushed gravel, crushed stone, or crushed slag, the bearing ratio will not be required.

The bearing ratio will be determined according to the Standard methods adopted by the Department.

A sample of the aggregate to be used shall be submitted to the Engineer at least 15 days prior to starting construction. The sample so submitted will be tested by the Department for acceptance.

Before the aggregate is deposited on the subgrade, it shall contain the amount of moisture required for compaction. The amount of moisture required shall be that determined by the Engineer for the material and compaction methods being used. The water and aggregate shall be mixed through a controlled aggregate mixing system. The system shall consist of a mechanical mixing device, and aggregate and water measuring devices, meeting the approval of the Engineer.

The granular material shall be compacted to not less than 100 percent of the standard laboratory density. The standard laboratory density shall be the maximum dry density determined according to AASHTO T 99 (Method C). A coarse particle correction according to AASHTO T 224 shall be used.

The dry density of the compacted base course, will be determined by the Engineer at regular intervals according to AASHTO T 191, Illinois Modified AASHTO T 310 (Direct Transmission Density/Backscatter Moisture), or by other methods approved by the Engineer.

If these tests indicate that the base course does not comply with the density requirements, additional wetting, if necessary, and rolling will be required until the density is obtained. Moisture shall be added to the material during compaction only when it is necessary to increase the percentage of moisture to obtain the required density.

- (b) Type B. The moisture content shall be sufficient to prevent segregation of the aggregate. Water shall be added as required by the Engineer to obtain compaction satisfactory to the Engineer.

351.06 Tolerance in Thickness. The base course shall be constructed to the thickness shown on the plans. Thickness determinations will be made at such points as the Engineer may select. When the constructed thickness is less than 90 percent of the specified thickness shown on the plans, aggregate shall be added to obtain the required specified thickness.

351.07 At Bridges, Railroad Grade Crossings, and Existing Pavement. The base course adjacent to bridges, railroad grade crossings, and existing pavement shall be 3 in. (75 mm) (compacted) greater in depth than the typical section, with the surface at the established grade. The width at bridges and railroad grade crossings shall be the same as the typical section. At existing pavement, the width shall be as shown on the plans or as directed by the Engineer. This 3 in. (75 mm) increase in depth shall be made at a uniform rate in a distance of 50 ft (15 m). The cost of excavation in this transition shall be considered as included in the cost of the base course.

351.08 At Side Roads, Entrances, and Mailboxes. The material used at side roads, entrances, and mailbox turnouts shall be the same as that used to construct the base course.

After the shoulders have been completed, the subgrade shall be excavated and the bottom of the excavation shall be compacted in a manner approved by the Engineer. The earth excavated in preparing the subgrade shall be disposed of within the right-of-way, as directed by the Engineer, within a distance of 1000 ft (300 m) from the place of excavation.

The excavation, preparation of subgrade and disposal of surplus excavation shall be considered as included in the cost of the base course.

351.09 Shaping, Trimming, Finishing, and Opening to Traffic. All shaping, trimming, and finishing shall be according to Section 212. The road shall be opened to traffic according to Article 701.17(b)(1).

351.10 Maintaining. The Contractor shall maintain the base course until the entire section is accepted. In no case shall the maintenance period be less than ten days for any portion of the road.

In lieu of the above specified minimum ten day maintenance period, the Contractor, at his/her option, may elect to proof roll the completed aggregate base course. The test vehicle for proof rolling shall consist of a tandem axle truck loaded to a minimum gross weight of 40,000 lb (18,100 kg). Proof rolling shall consist of 40 passes in each lane of the completed aggregate base course. Any failures in the base that occur during the proof rolling shall be immediately repaired and shall be subjected to an additional five passes of the test vehicle after the initial 40 passes are completed. This process shall be repeated, if necessary, until all failed areas pass the proof rolling.

351.11 Method of Measurement. Aggregate used for base course will be measured for payment in tons (metric tons), cubic yards (cubic meters), or square yards (square meters) of the thickness specified. Aggregate used for maintenance will be measured for payment in tons (metric tons). The unit of measurement will be shown on the plans.

Water required to be added for compaction on the grade will not be measured for payment, but shall be considered as included in the cost of the item of work being constructed.

The requirements for the use of contract quantities and measured quantities shall be according to Articles 311.08(a) and 311.08(b), respectively.

351.12 Basis of Payment. This work will be paid for at the contract unit price per ton (metric ton), or cubic yard (cubic meter), for AGGREGATE BASE COURSE, TYPE A, or AGGREGATE BASE COURSE, TYPE B, or at the contract unit price per square yard (square meter) for AGGREGATE BASE COURSE, TYPE A or AGGREGATE BASE COURSE, TYPE B, of the thickness specified.

Additional aggregate required for maintenance will be paid for at the contract unit price per ton (metric ton) for AGGREGATE BASE COURSE, TYPE A or AGGREGATE BASE COURSE, TYPE B.

Except as specified above for the additional aggregate required for maintenance, the work of maintaining or proof rolling the completed aggregate base will not be paid for separately, but shall be considered as included in the unit prices bid for the construction items involved, and no additional compensation will be allowed.

SECTION 352. SOIL-CEMENT BASE COURSE

352.01 Description. This work shall consist of constructing a soil-cement base course composed of soil, portland cement, and water.

352.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement (Notes 1 & 2)	1001
(b) Soil for Soil-Cement Base Course	1009.03
(c) Water	1002
(d) Bituminous Materials (Note 3)	1032

Note 1. Bulk cement may be used for the traveling mixing plant method if the equipment for handling, weighing, and spreading the cement is approved by the Engineer.

Note 2. Either Type I or Type IA portland cement shall be used.

Note 3. The bituminous materials used for curing shall be emulsified asphalt RS-2, CRS-2, HFE 90, or HFE 150; rapid curing liquid asphalt RC-70; or medium curing liquid asphalt MC-70 or MC-250.

352.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Pneumatic-Tired Rollers	1101.01
(b) Tamping Rollers (Note 1)	1101.01
(c) Steel Wheel Rollers (Note 2)	1101.01
(d) Traveling Mixing Plant (Note 3)	1101.07

Note 1. The tampers shall be long enough to penetrate within 1 in. (25 mm) of the subgrade on the initial rolling.

Note 2. Steel wheel rollers shall weigh from 6 to 10 tons (5.5 to 9 metric tons) and shall weigh not less than 200 lb/in. (35 N/mm) nor more than 325 lb/in. (57 N/mm) width of roller.

Note 3. When more than 12,000 sq yd (10,000 sq m) of soil-cement base course are to be processed, a traveling mixing plant will be required together with any machine, or combination of machines, or equipment which will produce in one pass completed soil-cement base course meeting the requirements of these Specifications. Mixing devices approved by the Engineer may be used when less than 12,000 sq yd (10000 sq m) of soil-cement base course are to be processed.

CONSTRUCTION REQUIREMENTS

352.04 General. The soil-cement base course shall be constructed only when the temperature of the subgrade, measured 6 in. (150 mm) below the surface, is

above 50 °F (10 °C) and the ambient air temperature in the shade is above 45 °F (7 °C).

352.05 Proportioning. Proportioning shall be as follows.

- (a) **Samples.** Samples of the cement and the project soil(s) shall be obtained and submitted to the Engineer at least 90 days prior to the construction of the soil-cement base course. Sample sizes shall be a minimum of 25 lb (11 kg) for the cement and 200 lb (91 kg) for the project soil(s).
- (b) **Mix Design.** The actual proportions of cement, water, and soil will be determined by the Engineer prior to construction using the submitted samples. The Engineer reserves the right to make such adjustments in proportions as are considered necessary during the progress of the work.

In no case shall proportions or type of cement be changed during the progress of the work without permission from the Engineer.

352.06 Preparation of Subgrade. The area to be processed shall be shaped to the proper grade and cross section and shall be void of all vegetation and other objectionable material. In cut or at grade sections, the subgrade shall be prepared according to Articles 301.03 and 301.04; except the minimum immediate bearing value (IBV) of the soil, below the soil to be processed, shall be 3.0.

352.07 Pulverizing. The soil to be processed shall be scarified and pulverized prior to the application of the cement. Pulverizing shall be continued until the soil meets the gradation requirement specified in Article 352.10 and the moisture content of the soil does not exceed that which will permit a uniform mixture of soil and cement.

352.08 Application of Cement. The cement shall be applied uniformly on the soil. The application of cement shall be limited to such an area that all the operations specified in Articles 352.08 to 352.11, inclusive, will be continuous and completed during daylight hours; and the operations specified in Articles 352.09 to 352.11 inclusive, completed in six hours.

No equipment, except that used in spreading and mixing, will be allowed to pass over the spread cement, and this equipment shall be operated in such a manner as to avoid displacement of cement.

Cement which has been damaged by hydration due to rain prior to or during the mixing operations, has been damaged while spread contrary to the above mentioned requirements, or has been displaced by the Contractor's equipment or other traffic, shall be replaced.

352.09 Dry Mixing. Dry mixing of soil and cement will be required when mixing equipment other than a traveling mixing plant is used. Mixing shall be confined to the area and depth shown on the plans and shall be continued until the resulting mixture is homogeneous and uniform in appearance.

When any of the operations from the start of soil and cement mixing through final compaction are interrupted for more than 30 minutes for any reason, the entire

thickness of the base course shall be thoroughly loosened, reprocessed, and shall be completed within the specified time limits for these operations. When the uncompacted soil-cement mixture is wet by rain so that the average moisture content exceeds the tolerance given in Article 352.10 at the time of final compaction, the portion being processed shall be reconstructed according to this Specification.

352.10 Moist Mixing. Moist mixing shall be as follows.

- (a) With Equipment Other Than a Traveling Mixing Plant. If a traveling mixing plant is not used, water shall be immediately applied uniformly and incorporated into the dry-mixed soil and cement in quantities which will produce the required moisture content for the soil-cement mixture.

Water supply and pressure distributing equipment shall be provided which will ensure the application of all water required on the section being processed within three hours. Each application or increment of water shall be at least partially incorporated into the mixture, if necessary, to avoid excessive concentration of water on and near the surface.

After the last increment of water has been added, mixing shall be continued until a uniform mixture of soil, cement, and water is obtained. Particular care shall be exercised to ensure satisfactory moisture distribution along the edges of the section and for the full depth of treatment.

When water application and moist mixing is completed, the percentage of moisture in the fraction of the mixture passing a 1 in. (25 mm) sieve, on a basis of dry weight (mass), shall be between 80 and 100 percent of the optimum moisture content for sandy soils, and between 100 and 120 percent of the optimum moisture content for silty and clayey soils. At completion of moist mixing, 100 percent of the soil shall pass a 1 in. (25 mm) sieve and at least 80 percent shall pass a No. 4 (4.75 mm) sieve, exclusive of gravel or stone retained on these sieves.

- (b) With a Traveling Mixing Plant. After the cement is applied, it shall be mixed with soil and water with the traveling mixing plant. No mixing shall be done below the desired depth. Mixing shall be at such rate that, or shall be repeated until, a uniform mixture of soil, cement, and water is obtained. Particular care shall be exercised to ensure a satisfactory mixture along the edges of the section and for the full depth of treatment. At the completion of the mixing operation, the moisture content and gradation of the mixture shall be as specified in Article 352.10(a).

352.11 Compaction and Finishing. Compaction of the soil-cement mixture shall be a continuation of the moist mixing operation such that the soil-cement mixture does not remain undisturbed after mixing and before compacting for more than 30 minutes. Prior to the beginning of compaction, the mixture shall be in a loose condition for its full depth and width. The mixture shall then be uniformly compacted with tamping rollers in conjunction with other compaction equipment until the specified density has been obtained. Particular care shall be exercised to ensure satisfactory density along the edges of the section and adjacent to construction joints. The type, size, number of compactors, and the rate of their operation shall be such that the section being processed can be compacted within two hours.

When initial compaction of the soil-cement mixture is nearing completion, the surface of the base course shall be shaped to the required lines, grades, and cross section, and compaction continued until the required density is obtained. If necessary to attain satisfactory surface grade, the surface shall be lightly scarified with a nail drag, spike-tooth harrow, or weeder, and reshaped. The resulting surface then shall be thoroughly rolled with a steel wheel roller, a pneumatic-tired roller, or both. The moisture content of the surface material shall be maintained at or slightly above its specified optimum during all finishing operations and until the curing material is applied.

Surface compaction and finishing shall be done in such a manner as to produce a smooth, closely knit surface, relatively free from cracks, ridges, low spots, or loose material, conforming to the crown, grades, and lines shown on the plans. When directed by the Engineer, surface finishing methods may be varied, provided a smooth, dense, uniform surface, free of surface compaction planes is produced.

The compacted soil-cement base course shall have a minimum dry density of 95 percent of the laboratory standard dry density. The in-place dry density will be determined according to AASHTO T 191, or Illinois Modified AASHTO T 310 (Direct Transmission Density/Backscatter Moisture). The laboratory standard dry density will be determined according to AASHTO T 134 (Method B).

Any portion of the base course that has a density less than 95 percent of the standard laboratory density shall be corrected or removed and replaced.

352.12 Compressive Strength. Prior to compaction, the Engineer will obtain random samples from the field design mixture, to be tested for the compressive strength according to AASHTO T 22. The samples will be compacted according to AASHTO T 134 (Method B), moist cured for seven days, and will be capped and soaked four hours immediately prior to compression testing. The compacted, cured specimens shall have a minimum seven day compressive strength of 500 psi (3500 kPa) or a specified design strength, whichever is greater. Any portion of the base course that has less than the required compressive strength shall be corrected or removed and replaced.

352.13 Protection and Cover. After the soil-cement base course has been finished, it shall be protected against drying for a period of seven days by applying a bituminous material according to Article 312.14; except, in no event shall the finished soil-cement base course remain without cover for more than 14 hours unless prolonged rain intervenes.

352.14 Construction Joints. At the end of each day's construction, a straight transverse construction joint shall be formed by cutting back into the completed work to form a vertical face. Damage to completed work shall be avoided. The base course shall be constructed and finished full width each day without longitudinal joints.

352.15 Opening to Traffic. The base course shall be opened to traffic according to Article 701.17(b)(2).

352.16 Maintenance. The Contractor shall maintain the entire base course in a manner satisfactory to the Engineer until the surface course has been constructed. Maintenance shall include immediate repairs of any defective or damaged portions of the base course. Repairs or replacements shall be made in such a manner as to ensure restoration of a uniform surface and durability of the portion repaired or replaced.

352.17 Tolerance in Thickness. Soil-cement base course shall be constructed to the thickness shown on the plans. Determination of base thickness will be based on thickness measurements at cored points taken at locations selected by the Engineer. Any portion of the soil-cement base course that is less than 90 percent of the specified thickness shall be removed and replaced with new material to the correct thickness.

352.18 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. The work will be measured for payment as follows.
 - (1) Processing of soil-cement base course will be measured for payment in place and the area computed in square yards (square meters).
 - (2) Cement incorporated in the soil-cement mixture will be measured for payment in hundredweights (kilograms), but payment will not be made for cement in excess of 105 percent of the amount specified by the Engineer.
 - (3) Removal and disposal of unstable and/or unsuitable material will be measured for payment according to Article 202.07(b).
 - (4) Replacement of unstable and/or unsuitable material will be measured for payment according to Article 204.07(b).
 - (5) Cement treatment of unstable subgrade soil, when specified by the Engineer, will be measured for payment according to (1) and (2) above.

352.19 Basis of Payment. This work will be paid for at the contract unit prices as follows.

- (a) Per square yard (square meter) for PROCESSING SOIL-CEMENT BASE COURSE, of the thickness specified.
- (b) Per hundredweight (kilogram) for CEMENT.
- (c) Removal and disposal of unstable and/or unsuitable material will be paid for according to Article 202.08.
- (d) Replacement of unstable or unsuitable material will be paid for according to Article 204.08.

- (e) Cement treatment of unstable subgrade soil, when specified by the Engineer, will be paid for at the contract unit prices for (a) and (b) above.

SECTION 353. PORTLAND CEMENT CONCRETE BASE COURSE

353.01 Description. This work shall consist of constructing a portland cement concrete base with or without reinforcement as specified.

353.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Reinforcement Bars	1006.10
(c) Longitudinal Metal Joints, Pins, and Bar Supports	1006.11(a)

353.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Forms	1103.05
(b) Formless Paver	1103.16
(c) Subgrade Planer	1103.08
(d) Subgrade Machine	1103.09
(e) Finishing Machine	1103.13
(f) Concrete Finisher Float or Mechanical Longitudinal Float ...	1103.14-1103.15
(g) Vibrator	1103.12, 1103.17
(h) Miscellaneous Equipment	1103.17
(i) Membrane Curing Equipment	1101.09

CONSTRUCTION REQUIREMENTS

353.04 General. The use of slip form paving will be permitted at the option of the Contractor. If the Contractor cannot obtain satisfactory results without the use of forms, the Department reserves the right to require the use of forms at no additional cost to the Department.

These items of work shall be according to the following requirements.

Item	Article/Section
(a) Preparation of Subgrade or Subbase	420.04
(b) Joints	420.05
(c) Removing Forms	420.11
(d) Slip Form Method	420.14
(e) Temperature Control for Placement	1020.14
(f) Tolerance in Thickness	420.15
(g) Bridge Approach Pavement	420.16
(h) Opening to Traffic	701.17(c)(5)

353.05 Forms and Form Setting. Forms and form setting shall be according to Article 420.06, except that the use of a mechanical form tamper will not be required.

353.06 Placing Concrete. Placing concrete shall be according to Article 420.07, except that a mechanical concrete spreader will not be required. When the base course is to be struck off and consolidated by either the vibrating screed method or the hand method, the concrete adjacent to both side forms shall be compacted with a vibrator inserted into the concrete and worked along the entire length of the forms before the finishing operations are started.

Trucks or equipment will be permitted on the finished subgrade or subbase, when permitted by the Engineer. Approval will be withdrawn if rutting develops in the subgrade or subbase which would reduce the plan thickness of the base course.

353.07 Transverse Construction Joints. Transverse construction joints shall be constructed according to Article 420.05(e), except that No. 6 (No. 20) tie bars 36 in. (900 mm) long shall be centered across the joint on 15 in. (375 mm) spacings.

353.08 Adjacent to Railroad Grade Crossing. Portland cement concrete base course adjacent to railroad grade crossing shall be constructed according to Article 420.17, except when the mainline portland cement concrete base course thickness is greater than 9 in. (225 mm), the thickness of the portland cement concrete base course adjacent to the railroad grade crossing shall be constructed to the same thickness as the mainline.

The HMA plug adjacent to railroad grade crossings shall be constructed of HMA binder course mixture according to the applicable requirements of Section 406. At the Contractor's option, HMA surface course mixture may be used in lieu of the binder course mixture.

353.09 Adjacent to Bridge Approach Pavement or Existing Pavement. The HMA plug adjacent to bridge approach pavement or existing pavement shall be constructed of HMA binder course mixture according to the applicable requirements of Section 406. At the Contractor's option, HMA surface course mixture may be used in lieu of the binder course mixture.

353.10 Final Strike Off, Consolidation, and Finishing. The concrete shall be struck off, consolidated, and finished according to Article 420.09, except the straightedging specified under Article 420.09(c) shall be performed until the entire surface does not vary more than 3/16 in. (5 mm) from the straightedge and the final finish shall be according to Article 420.09(e)(2).

353.11 Surface Test. The finished surface of the base course shall be within the tolerance of the following surface trueness test.

The base course will be tested for trueness in each wheel lane at the expiration of the required curing or protection period. The surface will be tested by means of a 16 ft (5 m) straightedge placed parallel to the centerline of the base course, parallel to the grade line and touching the surface. Surface variations which exceeds 3/8 in. (10 mm) will be marked and shall be removed by an approved grinding device consisting of multiple saws. The use of a bushhammer or other impact devices will

not be permitted. Determination of base course thickness will be made after the removal of high spots.

353.12 Tolerance in Thickness. The thickness of base course pay items that individually contain at least 1000 sq yd (840 sq m) of contiguous area, except for temporary construction, bike paths, and individual locations less than 500 ft (150 m) long, will be evaluated. Temporary construction is defined as those areas constructed and removed under the same contract. If the base course cannot be cored for thickness prior to placement of the cover layer(s), the Engineer will determine the thickness of the cover layer(s), and subtract them from the measured core thickness to determine the base course thickness.

The procedure described in Article 407.10(b) will be followed, except the option of correcting deficient pavement with additional lift(s) shall not apply.

353.13 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Portland cement concrete base course will be measured in place and the area computed in square yards (square meters). The width shall be as shown on the plans or as directed by the Engineer.

Reinforcement bars will be measured in pounds (kilograms) according to Article 508.07. Tie bars will be measured according to Article 508.07.

HMA plugs at railroad grade crossings, bridge approach pavement, or existing pavement will be measured for payment in tons (metric tons) according to Article 406.13.

353.14 Basis of Payment. This work will be paid for at the contract unit prices per square yard (square meter) for PORTLAND CEMENT CONCRETE BASE COURSE and HIGH-EARLY-STRENGTH PORTLAND CEMENT CONCRETE BASE COURSE, of the thickness specified.

Reinforcement bars in special concrete slabs will be paid for according to Article 508.08.

The unit prices bid for the various items of portland cement concrete base course shall include any added thickness of base course adjacent to railroad grade crossings.

HMA plugs at railroad grade crossings, bridge approach pavement, or existing pavement will be paid for at the contract unit price per ton (metric ton) according to Article 406.14 for HOT-MIX ASPHALT BINDER COURSE, of the mixture composition and Ndesign specified.

SECTION 354. PORTLAND CEMENT CONCRETE BASE COURSE WIDENING

354.01 Description. This work shall consist of widening existing pavement with a portland cement concrete base course widening not exceeding 6 ft (1.8 m) in width.

354.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020

354.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Forms	1103.05
(b) Finishing Machine	1103.13
(c) Vibrator	1103.12, 1103.17
(d) Miscellaneous Equipment	1103.17
(e) Membrane Curing Equipment	1101.09(c)

CONSTRUCTION REQUIREMENTS

354.04 General. The methods used in performing the following items of work shall be according to the requirements shown in the Articles listed below. The use of slip form methods for base course widening will be permitted at the option of the Contractor.

Item	Article/Section
(a) Removing Forms	420.11
(b) Temperature Control for Placement	1020.14
(c) Opening and Keeping Road Open to Traffic	701.17(c)(5)

354.05 Subgrade. The subgrade shall be prepared according to Article 420.04, except as follows.

- (a) The subgrade excavation shall be to the required depth for at least the full width of the proposed base course widening prior to placing the concrete. Excavation of the subgrade shall be as specified in Article 202.06.
- (b) The subgrade shall be rolled with a roller of a type approved by the Engineer. It shall be not less than 12 in. (300 mm) in width and shall weigh from 50 to 100 lb/in. (9 to 18 N/mm) of width of the roller.
- (c) Truck mixers or trucks will be permitted on the finished subgrade when approved by the Engineer. Approval will be withdrawn if rutting develops in the subgrade or subbase which reduces the plan thickness of the base course.

354.06 Constructing Without Forms. If the base course widening is constructed without forms, the following requirements shall apply.

- (a) The concrete shall be placed on the subgrade in a manner which will not cause segregation and which will meet the approval of the Engineer. It shall be struck off to the required elevation and properly consolidated. Consolidation shall be obtained by the use of internal vibration and by a mechanical surface vibrator or tamper, or one or more oscillating screeds. After the concrete has been consolidated, the surface of the concrete shall be finished by means of a metal plate. The plate shall be the full width of the widening and shall have a length of not less than 3 ft (1 m). The plate shall exert sufficient pressure on the concrete to produce a smooth and even surface.
- (b) The outer edge of the base course widening shall be supported for its full depth during the placing, consolidating, and finishing of the concrete by a vertical slip form and thereafter by earth banked against the edge, except that if the consistency and consolidation of the concrete and the equipment and method used are such that the concrete will retain its form satisfactorily, the earth support may be omitted.
- (c) The device used to construct the base course widening shall be guided by the edge of the existing pavement, and it shall ride exclusively on the existing pavement.

354.07 Constructing With Forms. If the base course widening is constructed with forms, the following requirements shall apply.

- (a) Forms and Form Setting. Forms and form setting shall be according to the requirements of Article 420.06, except a mechanical form tamper will not be required.
- (b) Placing Concrete. Concrete shall be placed according to Article 420.07, except that a mechanical concrete spreader will not be required. Spreading with shovels will be permitted. The base course widening may be struck off and consolidated by any of the three methods listed in Article 420.09(a). The concrete adjacent to the side form and the existing pavement shall be compacted with a vibrator inserted into the concrete and worked along the entire length of the side form and the existing pavement before the finishing operations are started.
- (c) Final Strike Off and Finishing. The concrete shall be finished to an even and uniform surface by the use of hand floats or other approved methods.

354.08 Reserved.

354.09 Tolerance in Thickness. The thickness of base course widening pay items that individually contain at least 1000 sq yd (840 sq m) of contiguous area, except for temporary construction; bike paths and individual locations less than 3 ft (1 m) wide or 1000 ft (300 m) long, will be evaluated. Temporary construction is defined as those areas constructed and removed under the same contract. If the base course widening cannot be cored for thickness prior to placement of the cover layer(s), the Engineer will determine the thickness of the cover layer(s), and subtract

them from the measured core thickness to determine the base course widening thickness.

The procedure described in Article 407.10(b) will be followed, except:

- (a) The width of a unit shall be the width of the widening along one edge of the pavement.
- (b) The length of the unit shall be 1000 ft (300 m).
- (c) The option of correcting deficient pavement with additional lift(s) shall not apply.

354.10 Backfill at Edge. Within 24 hours after completion of the base course widening, the remaining portion of the widening trench shall be backfilled as specified in Article 202.06. Prior to opening the base course widening to traffic, the Contractor shall compact the earth backfill adjacent to the base course. Compaction shall be obtained with a pneumatic-tired roller, to the satisfaction of the Engineer.

354.11 Earth Shoulders. At locations where no provisions have been made for the repair or improvement of the earth shoulders, they shall be left in as good a condition as they were before work was started. Such work as the Contractor may have to perform to meet this requirement shall be performed at no additional cost to the Department.

354.12 Method of Measurement. Portland cement concrete base course widening will be measured for payment according to Article 353.12.

354.13 Basis of Payment. Where the Department requires that portland cement concrete be used, this work will be paid for at the contract unit prices per square yard (square meter) for PORTLAND CEMENT CONCRETE BASE COURSE WIDENING and HIGH-EARLY-STRENGTH PORTLAND CEMENT CONCRETE BASE COURSE WIDENING, each of the thickness specified.

When the Contractor has the option of using either portland cement concrete or HMA according to Section 356, the work will be paid for at the contract unit price per square yard (square meter) for BASE COURSE WIDENING, of the thickness specified.

SECTION 355. HOT-MIX ASPHALT BASE COURSE

355.01 Description. This work shall consist of constructing hot-mix asphalt (HMA) base course on a prepared subgrade.

355.02 Materials. Materials shall be according to Section 1030.

The mixture composition used shall be IL-25.0 or IL-19.0.

355.03 Equipment. Equipment shall be according to Article 406.03.

CONSTRUCTION REQUIREMENTS

355.04 Subgrade. The subgrade shall be prepared according to Section 301, except Articles 301.05 and 301.06 will not apply, or according to Section 302 when soil modification is used.

355.05 Placing. HMA base course shall be placed according to Article 407.06 and the following.

- (a) The top lift thickness shall be 2 1/4 in. (60 mm) for mixture composition IL-19.0 or 3 in. (75 mm) for mixture composition IL-25.0.
- (b) When placing HMA base course adjacent to an existing pavement, the exposed edge of the existing pavement shall be cleaned of loose material to the satisfaction of the Engineer.

355.06 Compaction. The HMA base course shall be compacted according to Article 406.07.

355.07 Hauling. Hauling on newly placed HMA base course shall be according to Article 407.08.

355.08 Surface Test. The completed base course will be tested for trueness in each wheel lane by means of a 16 ft (5 m) straightedge placed parallel to the centerline of the pavement, parallel to the grade line and touching the surface. Surface variations of the base measured from the base of the straightedge to the surface of the pavement shall not exceed 3/8 in. (10 mm). Areas which have variations exceeding 3/8 in. in 16 ft (10 mm in 5 m) shall be corrected as directed by the Engineer.

355.09 Tolerance in Thickness. The thickness of HMA base course pay items that individually contain at least 1000 sq yd (840 sq m) of contiguous area, except for temporary construction; bike paths and individual locations less than 500 ft (150 m) long, will be evaluated according to Article 407.10(b). Temporary construction is defined as those areas constructed and removed under the same contract. If the base course cannot be cored for thickness prior to placement of the cover layer(s), the Engineer will determine the thickness of the cover layer(s), and subtract them from the measured core thickness to determine the base course thickness.

355.10 Method of Measurement. HMA base course will be measured for payment according to the requirements of Article 353.12.

355.11 Basis of Payment. This work will be paid for at the contract unit price per square yard (square meter) for HOT-MIX ASPHALT BASE COURSE, of the thickness specified.

SECTION 356. HOT-MIX ASPHALT BASE COURSE WIDENING

356.01 Description. This work shall consist of widening existing pavement with a hot-mix asphalt (HMA) base course widening not exceeding 6 ft (1.8 m).

356.02 Materials. Materials shall be according to Article 355.02.

356.03 Equipment. Equipment shall be according to Article 406.03. A mechanical spreader meeting the approval of the Engineer shall be used to place the HMA.

CONSTRUCTION REQUIREMENTS

356.04 Subgrade. The material adjacent to the edge of the existing pavement shall be excavated for the full width required and to the required depth according to Section 202.

The subgrade shall be prepared according to Section 301, except Articles 301.05 and 301.06 will not apply.

The completed subgrade shall be compacted according to Article 354.05(b).

356.05 Placing. The HMA base course widening shall be placed according to Article 406.06, except for the following.

- (a) Prior to placing the HMA, the exposed edge of all existing pavement shall be cleaned of loose material to the satisfaction of the Engineer.
- (b) The HMA shall be placed in two or more lifts, subject to the lift thickness requirements of Article 406.06(d), as necessary to obtain the required density. A minimum of two rollers will be required. While compacting the top lift, the rollers shall be kept off the edge of the existing pavement.
- (c) Only one lift of HMA shall be placed in a day, regardless of its thickness, unless otherwise authorized by the Engineer. The maximum lift thickness shall be 6 in. (150 mm).

356.06 Compaction. The HMA base course widening shall be compacted according to Article 406.07.

356.07 Tolerance in Thickness. The thickness of HMA base course widening pay items that individually contain at least 1000 sq yd (840 sq m) of contiguous area, except for temporary construction; bike paths and individual locations less than 3 ft (1 m) wide or 1000 ft (300 m) long, will be evaluated according to Article 407.10(b) except, the width of a unit shall be the width of the widening along one edge of the pavement and the length of a unit shall be 1000 ft (300 m). Temporary locations are defined as those constructed and removed under the same contract. If the base course widening cannot be cored for thickness prior to placement of the cover layer(s), the Engineer will determine the thickness of the

cover layer(s) and subtract them from the measured core thickness to determine the base course widening thickness.

356.08 Backfill at Edge of Widening. Backfilling at the edge of widening shall be performed as specified in Article 354.10.

356.09 Earth Shoulders. Earth shoulders shall be constructed according to Article 354.11.

356.10 Method of Measurement. HMA base course widening will be measured for payment according to Article 353.12.

356.11 Basis of Payment. Where the Department requires that HMA be used, this work will be paid for at the contract unit price per square yard (square meter) for HOT-MIX ASPHALT BASE COURSE WIDENING, of the thickness specified.

When the Contractor has the option of using either portland cement concrete as outlined in Section 354 or HMA according to Section 356, the work will be paid for at the contract unit price per square yard (square meter) for BASE COURSE WIDENING, of the thickness specified.

SECTION 357. POZZOLANIC STABILIZED BASE COURSE

357.01 Description. This work shall consist of constructing pozzolan stabilized base course.

357.02 Materials. Materials shall be according to Article 312.16 and the following.

Item	Article/Section
(a) Hot-Poured Joint Sealer	1050.02

357.03 Equipment. Equipment shall be according to Article 312.17 and the following.

- (a) Heating Equipment for Joint Sealant (Note 1)

Note 1. The heating equipment shall be of an indirect heating type with positive temperature control, mechanical agitation, and recirculating pump.

CONSTRUCTION REQUIREMENTS

357.04 General. The requirements for constructing pozzolan stabilized base course shall be according to Articles 312.18 - 312.23. References in these Articles to subbase and pozzolan stabilized mixture shall be construed to include base course and pozzolan stabilized base course, respectively. The subgrade shall be prepared according to Section 301, except Articles 301.05 and 301.06 will not apply.

In addition to the requirements of Article 312.23, transverse joints shall be constructed full plan width of the completed base course and sealed with hot-poured joint sealer. When base course is constructed adjacent to existing pavement, this joint will not be required. Joints shall be located at spacings of 30 ft (9 m) perpendicular to the centerline. Construction and sealing of the joints shall be performed as shown on the detail drawing included in the plans or as directed by the Engineer.

The base course portion of the joint shall be cut within 72 hours of base course compaction. This portion may be cut separately or in conjunction with the surface course portion if the 72 hour requirement can be met. The location of the joint in the surface portion shall not vary by more than 3/16 in. (5 mm) from the location of the joint in the base course.

Sealing of the surface course joints shall be performed according to Article 420.12, except that sealing shall commence immediately upon sawing of the joint.

The finished base course may be opened to local traffic 36 hours after the finishing operation unless otherwise directed by the Engineer, and to all traffic after placement of surface course.

Contraction joints shall be established in all base removed and replaced over 30 ft (9 m) in length.

357.05 Tolerance in Thickness. Tolerance in pozzolanic stabilized base course thickness shall be as specified in Article 352.17.

357.06 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Pozzolanic stabilized base course of the thickness specified will be measured for payment in place and the area computed in square yards (square meters). The width for measurement will be the width of the top of the base course as shown on the plans or as directed by the Engineer. The liquid asphalt for the curing coat, any sand required, and the construction and sealing of contraction joints will not be measured for payment, but shall be considered as included in the contract unit price bid for pozzolanic stabilized base course.

357.07 Basis of Payment. This work will be paid for at the unit price per square yard (square meter) for POZZOLANIC STABILIZED BASE COURSE, of the thickness specified.

SECTION 358. REPAIR AND PREPARATION OF BASE COURSE

358.01 Description. This work shall consist of the repair and preparation of existing surfaces, which are to be used as bases for the various types of surface courses.

358.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate	1004.04

358.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Pneumatic-Tired Rollers	1101.01
(b) Mechanical Sweeper	1101.03

CONSTRUCTION REQUIREMENTS

358.04 Aggregate Bases. All loose materials on the surface of the proposed base course which are of such size, gradation, and quality that they can be utilized, shall be bladed to the shoulders and left in windrows together with any material already in windrows or stockpiles. All such materials shall be incorporated in the work or disposed of as directed by the Engineer. The repair and preparation of newly constructed bases shall not be undertaken until it has been opened to traffic for a period of not less than ten days.

- (a) Repairs. All failures (potholes, deep depressions, or ruts) occurring in the existing surface to be used as the base, shall be repaired by scarifying, removing all foreign material, and reshaping. If additional material is needed to bring the surface to the required cross section, CA 6 aggregate shall be used. The repaired areas shall then be compacted thoroughly by means of a pneumatic-tired roller or a hand tamper as directed by the Engineer. If the moisture content of the aggregate is such that compaction satisfactory to the Engineer cannot be obtained, water shall be added.
- (b) Preparation. After the repairs have been made in the base course, any area having ruts, depressions, corrugations, excessive crown, or loose material shall be brought to a smooth grade and proper crown by repeatedly wetting with water applied by means of a sprinkler, blading with a road grader or multiple blade maintainer, and rolling with a pneumatic-tired roller. The base course shall be bladed lightly to such a depth that sufficient material will be obtained to true up the surface of the base course. During the smoothing operations, the roadbed from the edges of the base to the shoulder lines shall be bladed to a smooth uniform slope so that the surface will drain and not impound water.

After the surface of the base course has been brought to a smooth grade and proper crown, it shall be compacted by repeated wetting and rolling with a pneumatic-tired roller for a period of not less than two days. During this

time, the surface shall be kept in a damp condition. Before a prime coat is applied, the base shall be surface dry, but at no time shall the period of drying be less than 24 hours. When required by the Engineer, the base course shall be swept with a mechanical sweeper or hand brooms before a prime coat is applied. The sweeping shall be continued until all dust, mud and foreign material are removed. Traffic shall not be allowed upon the prepared base course after the final sprinkling, or, if a bituminous prime coat has been applied, until the Engineer has approved the penetration of the prime coat.

358.05 Old Bituminous, Brick, and Concrete. Repair of old bituminous, brick, and concrete bases shall be as follows.

- (a) Repair. All loose and defective material shall be removed from all holes, ruts, or depressions in the existing surface. These areas shall then be filled as provided in the contract.
- (b) Preparation. After the base course has been patched and permitted to cure, it shall be cleaned by means of a mechanical sweeper, hand brooms, flushing with water, or by other approved methods. Special care shall be taken to clean the surface of the base course adjacent to the edges, so that the full width of the surface to be treated will be clean. The surface of the base course shall be clean and dry when the surface course is placed.

358.06 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirement for use of contract quantities shall be according to Article 202.07(a).
- (b) Measured Quantities. The work in connection with the repair and preparation of bases, except materials, will be measured for payment in place and the area computed in square yards (square meters).

If additional material is required for the repair of aggregate bases, it will be measured for payment in tons (metric tons) according to the requirements of Article 311.08(b).

If additional material is required for the repair of old bituminous, brick, or concrete bases, it will be measured for payment as provided for in the contract.

358.07 Basis of Payment. The work in connection with the repair and preparation of bases, except materials, will be paid for at the contract unit price per square yard (square meter) for PREPARATION OF BASE.

Additional material required for the repair of aggregate bases, will be paid for at the contract unit price per ton (metric ton) for AGGREGATE BASE REPAIR.

When the contract does not contain a unit price for the material required for the repair of any type base, it will be paid for according to Article 109.04.

DIVISION 400. SURFACE COURSES, PAVEMENTS, REHABILITATION, AND SHOULDERS

SECTION 401. RESERVED

SECTION 402. AGGREGATE SURFACE COURSE

402.01 Description. This work shall consist of furnishing and placing one or more courses of aggregate upon a prepared subgrade.

402.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate	1004.04
(b) RAP Material (Note 1)	1031

Note 1. Reclaimed Asphalt Pavement (RAP) may be used as aggregate in surface course for temporary access entrances.

402.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Tamping Rollers	1101.01
(b) Pneumatic-Tired Rollers	1101.01
(c) Three-Wheel Rollers (Note 1)	1101.01
(d) Tandem Rollers (Note 1)	1101.01
(e) Aggregate Spreaders	1102.04
(f) Vibratory Machine (Note 2)	

Note 1. Three-wheel or tandem rollers shall weigh 6 to 10 tons (5.5 to 9 metric tons) and shall weigh not less than 200 lb/in. (35 N/mm) nor more than 325 lb/in. (57 N/mm) of width of the roller.

Note 2. The vibratory machine shall meet the approval of the Engineer.

CONSTRUCTION REQUIREMENTS

402.04 Subgrade. The subgrade shall be prepared according to Section 301, except Article 301.07 shall not apply.

402.05 Type A Requirements. Aggregate surface course, Type A, shall be constructed according to Article 351.05 for Type A aggregate base course, except the bearing ratio requirements shall not apply.

402.06 Tolerance in Surface Course Type A Thickness. The surface course shall be constructed to the thickness shown on the plans. Thickness determinations will be made at such points as the Engineer may select. When the constructed thickness is less than 90 percent of the thickness shown on the plans, aggregate shall be added to obtain the required thickness.

402.07 Type B Requirements. Any one or two gradations of the material specified in Article 1004.04 shall be used except where two gradations of material are used, the change shall not be made at more than one location on the section.

The surfacing material shall be deposited on the subgrade by means of a spreader.

The equipment used shall be such that the required amount of material will be deposited uniformly along the central portion of the roadbed.

The material which has been deposited shall be spread immediately to the plan cross section. Hauling shall be routed over the spread material so it will cover the entire width of surface. If the equipment used in the hauling operations causes ruts extending through the spread material and into the subgrade, and the subgrade material is being mixed with the surfacing material, the equipment shall be removed from the work or the rutting otherwise prevented as directed by the Engineer.

The Contractor shall keep the surface smooth by dragging or blading as many times each day as the Engineer may direct.

Holes, waves, and undulations which develop and which are not filled by blading shall be filled by adding more material.

402.08 At Bridges, Railroad Grade Crossings, and Existing Pavement. The surface course adjacent to bridges, railroad grade crossings, and existing pavement shall have a depth equal to the thickness of the typical section at the bridge, railroad grade crossing or existing pavement with the surface at the established grade. The width at bridges and railroad grade crossings shall be 2 ft (600 mm) wider than the surface course width shown on the typical section. At existing pavement, the width shall be as shown on the plans or as directed by the Engineer. The depth and width transition at the bridge, railroad grade crossing or existing pavement shall be made at a uniform rate within a distance of 50 ft (15 m).

402.09 At Side Roads, Entrances, and Mailboxes. The same type and gradation of material used for constructing the surface course shall be used at side roads, entrances, and mailbox turnouts.

402.10 For Temporary Access. The Contractor shall construct and maintain an aggregate surface course for temporary roads, approaches, and entrances according to Article 402.07 and as directed by the Engineer.

The same type and gradation of material used to construct the temporary access shall be used to maintain it.

When use of the temporary access is discontinued, the surface aggregate used in its construction shall be removed and utilized in the permanent construction or disposed of according to Article 202.03.

402.11 Shaping, Trimming and Finishing. All shaping, trimming, and finishing shall be according to Section 212.

402.12 Method of Measurement. Aggregate used for aggregate surface course will be measured for payment in tons (metric tons), cubic yards (cubic meters), or square yards (square meters) of the thickness specified, according to the requirements of Article 311.08.

The cost of excavation for the transition at the bridge, railroad crossing, or existing pavement will not be measured for payment.

402.13 Basis of Payment. This work will be paid for at the contract unit price per ton (metric ton) for AGGREGATE SURFACE COURSE, TYPE A, or AGGREGATE SURFACE COURSE, TYPE B; or at the contract unit price per cubic yard (cubic meter) for AGGREGATE SURFACE COURSE, TYPE A; or AGGREGATE SURFACE COURSE, TYPE B; or at the contract unit price per square yard (square meter) for AGGREGATE SURFACE COURSE, TYPE A; of the thickness specified.

Aggregate for temporary access will be paid for at the contract unit price per ton (metric ton) for AGGREGATE FOR TEMPORARY ACCESS.

BITUMINOUS SURFACES AND HOT-MIX ASPHALT PAVEMENTS

SECTION 403. BITUMINOUS SURFACE TREATMENT (CLASS A-1, A-2, A-3)

403.01 Description. This work shall consist of constructing a single or multiple course bituminous surface treatment as indicated below.

- (a) A-1. A-1 shall consist of a bituminous seal coat material and a seal coat aggregate.
- (b) A-2. A-2 shall consist of a prime coat, a bituminous cover coat material and a cover coat aggregate, and a bituminous seal coat material and seal coat aggregate.
- (c) A-3. A-3 shall consist of a prime coat, two separate applications of a bituminous cover coat material and cover coat aggregate, and a bituminous seal coat material and seal coat aggregate.

403.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Cover Coat Aggregate	1004.03
(b) Seal Coat Aggregate (Note 1)	1004.03
(c) Bituminous Materials (Note 2)	1032

Note 1. For A-1 surface treatment, the contract will specify which of the two aggregate gradations itemized in Article 1004.03 shall be used.

Note 2. For A-1 surface treatment, the contract will specify the types and grades of bituminous materials to be used. For A-2 and A-3 surface treatments, the Contractor may use any one of the types of bituminous materials shown in the following table. When more than one grade is shown

Art. 403.02 Bituminous Surface Treatment (Class A-1, A-2, A-3)

for a particular type, the Engineer reserves the right to specify the grade which shall be used.

Type of Construction	Bituminous Materials Recommended for Weather Conditions Indicated	
	Warm [60 to 85 °F]* [(15 to 30 °C)]*	Hot [85 °F Plus]* [(30 °C Plus)]*
Prime	MC-30, PEP	MC-30, PEP
Cover Coat and Seal Coat	RS-2, CRS-2, MC-800, MC-3000, SC-3000, HFE-90, HFE-150, HFE-300	RS-2, CRS-2, MC-800, MC-3000, SC-3000, PG 46-28, PG 52-28, HFE-90, HFE-150, HFE-300

*Temperature of the air in the shade at the time of application.

403.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Pneumatic-Tired Rollers	1101.01
(b) Mechanical Sweeper	1101.03
(c) Aggregate Spreaders	1102.04
(d) Heating Equipment	1102.07
(e) Pressure Distributor	1102.05

CONSTRUCTION REQUIREMENTS

403.04 Weather Limitations. This work shall be done between May 1 and October 1. Bituminous materials shall be applied only when the temperature of the air in the shade is above 60 °F (15 °C). No work shall be started if local conditions indicate that rain is imminent.

This work may be done between October 1 and October 30 providing the temperature of the air for three consecutive days immediately preceding the day of application has been: (1) above 60 °F (15 °C) in the shade each day, (2) a minimum of 40 °F (5 °C) and (3) the temperature of the air in the shade at time of application is above 60 °F (15 °C).

403.05 Preparation of Bituminous Material. The temperature of the bituminous material at the time of application shall be such that it will spray uniformly without clogging the spraying nozzles and shall be applied within the temperature ranges according to Article 1032.04. Bituminous material delivered in tank cars may be heated by steam coils; that delivered in mobile tanks may be heated in asphalt tanks or in a pressure distributor. In all cases, precautions shall be taken to avoid danger of fire. If heated in asphalt tanks, the material shall be agitated during the heating period to prevent localized overheating. If heated in a pressure distributor, the material shall be circulated while it is being heated. All flames shall be extinguished during application of the bituminous material. In all methods of heating, means shall be provided to determine the temperature of the material at frequent

intervals to prevent it from being overheated or damaged. Emulsified asphalt received in tank cars or mobile tanks shall be agitated to secure uniformity of the emulsion before being used. Penetrating emulsified prime (PEP) shall be thoroughly agitated within 24 hours of application.

403.06 Preparation of Aggregate. The aggregates used in the cover coat(s) and the seal coat shall contain no free moisture.

403.07 Sequence of Work. The sequence of construction operations shall be undertaken as follows.

- (a) Repair and preparation of base or existing surface.
- (b) Application of bituminous material for prime coat (A-2 and A-3 only).
- (c) Alternate applications of bituminous material and aggregate.

403.08 Repair and Preparation of Base or Existing Surface. The base or existing surface shall be prepared according to Section 358.

403.09 Prime Coat. The bituminous material, as specified for prime coat in Article 403.02, shall be applied uniformly at the rate of 0.25 to 0.5 gal/sq yd (1 to 2 L/sq m), the exact rate to be specified by the Engineer. The bituminous priming material shall be applied to a width 1 ft (300 mm) greater on each side of the roadway than the specified width of the finished surface.

The prime coat shall be permitted to cure until the penetration has been approved by the Engineer, but not less than 24 hours. Pools of bituminous material occurring in the depressions shall be broomed or squeegeed over the surrounding surface the same day the prime coat is applied. Traffic shall not be allowed upon the primed surface during the curing period. At locations where the prime coat has failed or is damaged, it shall be repaired in a manner satisfactory to the Engineer. The prime coat shall be maintained at all times until the cover coat is constructed. When required by the Engineer, the primed surface shall be swept prior to constructing the cover coat.

403.10 Application of Bituminous Material. The bituminous material shall be applied with a pressure distributor. A hand spray bar shall be used at places which are not covered by the distributor. The entire length of the spray bar shall be set at the height above the surface recommended by the manufacturer for even distribution of the bituminous material. Any loss of bituminous material in handling due to faulty valves, leaking pipes, overflow due to excess, or other reasons, will be deducted from the amount due the Contractor.

The distributor shall be operated in a manner such that missing or overlapping will be avoided. To prevent overlapping of successive applications of bituminous material at transverse joints, heavy paper shall be spread over the previously applied bituminous material and aggregates. In order to obtain a uniform application of the bituminous material, the distributor shall be traveling at the speed required for the specified rate of application when the spray bar crosses the paper.

Art. 403.10 Bituminous Surface Treatment (Class A-1, A-2, A-3)

Adjacent construction, such as concrete pavement, curb and gutter, bridge floors, raised reflective pavement markers, and bridge handrails, shall be protected by shields, covers or other means. If bituminous material is applied to adjacent construction either by accident or because of inadequate protection, the Contractor shall remove such material.

If the Contractor is unable to obtain satisfactory application due to unsuitable or poorly regulated distributing equipment, or to incompetent operators, the Contractor shall immediately replace or repair such equipment, or furnish competent operators.

A spray bar operator shall be present at all times, on the rear platform of the distributor, during the application of the bituminous material.

The spray bar operator may be omitted from the rear platform, if the distributor is of such design that the quantity of bituminous material being placed is mechanically coordinated with the speed of the distributor, and the on-off controls and driver's visibility are such that no overlapping of successive applications of bituminous material and aggregates will occur.

403.11 Application of Aggregates. The cover coat and seal coat aggregates shall be spread evenly with an aggregate spreader over the entire surface being treated. In all cases, the aggregate shall be applied ahead of the truck or spreader wheels. Hand spreading will be permitted only when approved by the Engineer and, when so permitted, the aggregate shall be spread uniformly and at the approximate rate specified. Any ridges of aggregate left by the aggregate spreader shall be smoothed out with hand brooms immediately behind the aggregate spreader.

403.12 Cover Coat. Bituminous material for the cover coat shall not be applied until the previous application is acceptable to the Engineer.

At the beginning of each day's work, no bituminous material shall be applied until there is sufficient cover coat aggregate in trucks at the work site to completely cover the first application of bituminous material. The amount of surface area covered by each successive application of bituminous material shall be determined by the Engineer. In no case shall this area be greater than can be covered with cover coat aggregate and given the initial rolling while the bituminous material is still in condition to hold the aggregate.

The bituminous material, as specified for cover coat in Article 403.02, shall be applied uniformly over the surface at the rate of 0.20 to 0.5 gal/sq yd (1 to 2 L/sq m), the exact rate to be specified by the Engineer. Immediately following the application of the bituminous material, the cover coat aggregate shall be spread over the treated surface at the rate of 15 to 25 lb/sq yd (8 to 14 kg/sq m), the rate to be as specified by the Engineer.

The entire surface shall be rolled immediately with a pneumatic-tired roller. Rolling shall proceed in a longitudinal direction beginning at the edges and progressing toward the center, overlapping on successive trips by at least 1/2 the width of the roller. The roller shall be operated at a speed which will not cause the aggregate to be displaced. The aggregate shall then be rolled with a separate pneumatic-tired roller until the aggregate is properly seated in the bituminous material.

403.13 Seal Coat. When constructing A-2 or A-3, the seal coat shall not be started until the cover coat immediately preceding the seal coat is completed.

Application of the bituminous material and aggregate and rolling of the seal coat aggregate shall be the same as specified above in Article 403.12 for the cover coat.

During the construction period, the Contractor shall maintain the completed work. If necessary, the Contractor shall apply additional seal coat aggregate to absorb excess bitumen appearing on the surface and shall repair any areas where pickup has occurred.

Upon completion of the work and after final set of the asphalt, excesses of loose aggregate shall be removed by brooming the entire roadway surface with rotary type brooms.

403.14 Opening to Traffic. The road shall be opened to traffic according to Article 701.17(c)(4).

403.15 Method of Measurement. This work will be measured for payment as follows.

Bituminous materials will be measured for payment as specified in Section 1032.

Cover Coat Aggregate and Seal Coat Aggregate will be measured in tons (metric tons) according to the requirements of Article 311.08(b), except that measurement for payment will not be made for aggregate in excess of 110 percent of the amount specified by the Engineer.

403.16 Basis of Payment. This work will be paid for at the contract unit price per gallon (liter) for BITUMINOUS MATERIALS (PRIME COAT), BITUMINOUS MATERIALS (COVER AND SEAL COATS), and POLYMERIZED BITUMINOUS MATERIALS (COVER AND SEAL COATS); or at the contract unit price per ton (metric ton) for BITUMINOUS MATERIALS (PRIME COAT), BITUMINOUS MATERIALS (COVER AND SEAL COATS), and POLYMERIZED BITUMINOUS MATERIALS (COVER AND SEAL COATS); and per ton (metric ton) for COVER COAT AGGREGATE and SEAL COAT AGGREGATE.

When provided as a payment item, the preparation of the base or existing surface will be measured and paid for as specified in Section 358. If not provided as a payment item, preparation of base or existing surface shall be considered as included in the contract unit price(s) for the bituminous surface treatment.

SECTION 404. RESERVED

SECTION 405. RESERVED

SECTION 406. HOT-MIX ASPHALT BINDER AND SURFACE COURSE

406.01 Description. This work shall consist of constructing hot-mix asphalt (HMA) binder and/or surface course on a prepared base.

406.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Hot-Mix Asphalt	1030
(b) Bituminous Materials (Note 1)	1032
(c) Fine Aggregate	1003.03

Note 1. The bituminous material used for prime coat shall be one of the types listed in the following table. When more than one grade is shown for a particular type, the Engineer reserves the right to specify the grade which shall be used.

When emulsified asphalts are used, they shall be diluted with an equal volume of potable water. The HFE 90 shall be diluted by the manufacturer. The diluted material shall be thoroughly agitated within 24 hours of application and show no separation of water and emulsion. The diluted material shall not be returned to an approved emulsion storage tank.

Type of Construction	Bituminous Materials
Prime (tack) on Brick Concrete or HMA Bases	SS-1, SS-1h, CSS-1, CSS-1h HFE 90, RC-70, SS-1hP, CSS-1hP
Prime on Aggregate Bases	MC-30

406.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Self-Propelled Pneumatic-Tired Roller	1101.01
(b) Three-Wheel Rollers	1101.01
(c) Tandem Rollers	1101.01
(d) Vibratory Roller	1101.01
(e) Spreading and Finishing Machine (Note 1)	1102.03
(f) Pressure Distributor	1102.05
(g) Trench Roller	1101.01
(h) Pavement Surface Test Equipment	1101.10(a)

Note 1. When a notched wedge joint is required, the strike off device shall produce the notches and wedge of the joint and shall be adjustable. The device shall be attached to the paver and shall not restrict operation of the main screed.

The wedge roller shall have a minimum diameter of 12 in. (300 mm), a minimum weight of 50 lb/in. (9 N/mm) of width, and a width equal to the wedge. The roller shall be attached to the paver.

CONSTRUCTION REQUIREMENTS

406.04 Keeping Road Open to Traffic. The road shall be kept open to traffic according to Article 701.17(c)(3).

406.05 Preparation, Priming and Leveling of Brick, Concrete, HMA or Aggregate Bases. The base shall be prepared, primed, and leveled according to the following.

- (a) Preparation. On existing pavements, all excess crack filler and HMA patches which contain an excess of bitumen or which are unstable in hot weather shall be removed. All bitumen shall be removed from expansion joints and cracks more than 1 1/2 in. (38 mm) wide.

All open cracks and open expansion joints having a width of 1/2 in. (13 mm) or more, expansion joints and cracks that have been cleaned, and flangeways, shall be filled with mixture for cracks, joints, and flangeways. The mixture shall be hand tamped in place with hand tools.

All depressions of 1 in. (25 mm) or more in the surface of the existing pavement shall be filled with leveling binder. At locations where heavy disintegration and deep spalling exists, the area shall be cleaned of all loose and unsound material with pneumatic tools, or other approved equipment, primed, and filled with leveling binder (hand method).

Aggregate base shall be prepared according to Section 358.

Waste material produced during pavement preparation operations shall be removed at the close of each day's work and shall be disposed of according to Article 202.03.

- (b) Prime Coat. The base, or base and gutter shall be clean and dry. The bituminous priming material shall be prepared according to Article 403.05 and applied according to Article 403.10. When emulsified asphalt is used, the temperature in the shade shall be 60 °F (15 °C) or higher at time of application.
- (1) Brick, Concrete, or HMA Bases. The prime shall be applied at the rate of 0.05 to 0.10 gal/sq yd (0.2 to 0.5 L/sq m), the exact rate to be specified by the Engineer.

The prime coat (except emulsion type) shall be placed at least one hour in advance of the placement of HMA, but no more than five days in advance of the placement of HMA.

When an emulsified asphalt prime is used, the area to be primed shall be limited to that which can be covered with HMA the same day, unless otherwise permitted by the Engineer. HMA may be placed over emulsified asphalt primer when the emulsion has broken and all free moisture has evaporated or drained off the surface.

When directed by the Engineer, the prime coat shall be covered immediately following its application with fine aggregate mechanically spread at a uniform rate of 2 to 4 lb/sq yd (1 to 2 kg/sq m). The pavement shall be primed one lane at a time. The lane shall remain closed until the aggregate does not pickup under traffic. On multi-lane pavements, traffic will not be allowed on the primed surface and the traffic control shall be according to Article 701.18(e)(2). In all instances, the priming operation shall be performed in such a manner that a minimum amount of interference will be caused to traffic.

Where the road is closed to through traffic, the prime coat need not be covered with fine aggregate. At least one lane shall remain unprimed until the prime coat on the adjacent pavement has cured sufficiently and will not pick up under traffic.

- (2) **Aggregate Bases.** The prime shall be applied at the rate of 0.25 to 0.50 gal/sq yd (1 to 2 L/sq m), the exact rate to be specified by the Engineer.

The prime coat shall be permitted to cure until the penetration has been approved by the Engineer, but at no time shall the curing period be less than 24 hours. Pools of prime occurring in the depressions shall be broomed or squeegeed over the surrounding surface the same day the prime coat is applied. When directed by the Engineer, the prime coat shall be covered immediately following its application with fine aggregate mechanically spread at a uniform rate of 4 to 6 lb/sq yd (2 to 3 kg/sq m). The base shall be primed 1/2 width at a time. The prime coat on the second half/width shall not be applied until the prime coat on the first half/width has cured so that it will not pick up under traffic. In all instances, the priming operations shall be performed in such a manner that a minimum amount of interference will be caused to traffic.

When the road is closed to traffic, the bituminous prime coat material need not be covered with fine aggregate.

- (c) **Leveling Binder.** The mixture composition used for leveling binder shall be as listed in the following table.

Leveling Binder	
Nominal, Compacted, Leveling Binder Thickness, in. (mm)	Mixture Composition
≤ 1 1/4 (32)	IL-4.75, IL-9.5, or IL-9.5L
> 1 1/4 to 2 (32 to 50)	IL-9.5, IL-12.5, or IL-9.5L

The density requirements of Article 406.07(c) shall apply for leveling binder, machine method, when the nominal compacted thickness is: 3/4 in. (19 mm) or greater for IL-4.75 mixtures; 1 1/4 in. (32 mm) or greater for IL-9.5 and IL-9.5L mixtures; and 1 1/2 in. (38 mm) or greater for IL-12.5 mixtures.

- (1) Machine Method. Leveling binder placed with a finishing machine will be designated as leveling binder (machine method).

Where areas to be leveled are greater than 2 in. (50 mm) in depth, the leveling binder shall be placed and compacted in lifts not exceeding maximum depth of 2 in. (50 mm). The total thickness of leveling binder placed in one day will be limited to 4 in. (100 mm), unless otherwise directed by the Engineer.

- (2) Hand Method. Leveling binder placed other than with a finishing machine will be designated as leveling binder (hand method). Leveling binder (hand method) shall be compacted with a roller to the satisfaction of the Engineer. Hand tamping will be permitted when approved by the Engineer.

406.06 Placing. The HMA shall be placed according to the following.

- (a) Start of Mix Production and Job Mix Formula (JMF) Adjustments, (TEST STRIP). Test strip construction shall be according to Article 1030.06.
- (b) Placement Conditions. Placement of HMA shall be under the following conditions.
 - (1) General Conditions. HMA shall be placed on a clean, dry base and when weather conditions are suitable. The leveling binder and binder courses shall be placed only when the temperature in the shade is at least 40 °F (5 °C) and the forecast is for rising temperatures. The surface course shall be placed only when the air temperature in the shade is at least 45 °F (8 °C) and the forecast is for rising temperatures.

The HMA shall be delivered at a temperature of 250 to 350 °F (120 to 175 °C).

Intermingling of different mixture compositions at any one paver will not be permitted.

- (2) Special Conditions for mixture IL-4.75.
 - a. The surface shall be dry for at least 24 hours, and clean, prior to placement of the mixture.
 - b. Work shall not begin when local conditions indicate rain is imminent.
 - c. The mixture shall be placed only when the temperature in the shade is at least 50 °F (10 °C) and the forecast is for rising temperatures.
 - d. The mixture temperature shall be 310 to 350 °F (155 to 175 °C) and shall be measured in the truck just prior to placement.

- e. When used as leveling binder, the mixture shall be overlaid within five days of being placed.
- (c) Field Conditions. HMA shall be placed and compacted during daylight, unless artificial light satisfactory to the Engineer is provided.

In the event of sudden rain, the loading of trucks at the plant or from storage bins shall immediately stop. Material in transit will be permitted to be laid at the Contractor's risk providing the pavement is free of standing water and the proper temperature of the HMA is maintained. Approval to unload the trucks in transit shall in no way relax the requirements for quality, density, or smoothness of the HMA being placed.

- (d) Lift Thickness. The minimum compacted lift thickness for constructing HMA binder and surface courses shall be as follows.

MINIMUM COMPACTED LIFT THICKNESS	
Mixture Composition	Thickness, in. (mm)
IL-9.5, IL-9.5L	1 1/4 (32)
IL-12.5	1 1/2 (38)
IL-19.0, IL-19.0L	2 1/4 (57)
IL-25.0	3 (75)

The minimum and maximum compacted lift thickness for mixture IL-4.75 shall be 3/4 in. (19 mm) and 1 1/4 in. (32 mm) respectively.

- (e) Spreading and Finishing. The HMA shall be placed with a spreading and finishing machine to the typical section and grade shown on the plans or as established by the Engineer. On areas where irregularities, inaccessibility, or unavoidable objects make the use of mechanical spreading and finishing impractical, as determined by the Engineer, the HMA may be spread, raked, and luted by hand.

When placing HMA within 200 ft (60 m) of a bridge abutment, the automatic electronic grade control on the paver shall be operated from a preset grade control stringline. At all other locations, a preset grade control stringline or a grade reference device traveling on the adjacent pavement surface shall be used. When traffic interference or sharp curves make the minimum 30 ft (9 m) device impractical, the grade reference device may be shortened to no less than 10 ft (3 m) as directed by the Engineer.

The operating speed of the paver shall not exceed that speed which is necessary to produce a uniformly spread and struck off mat having a smooth texture without tearing or segregation. The paver speed shall be mated with the required roller speed and shall not exceed that which coincides with the average rate of delivery of HMA to the paver to provide, as nearly as possible, continuous operation of the paver. In no case shall the speed of the paver exceed 50 ft (15 m) per minute.

A stringline shall be used as a guide for the finishing machine in order to maintain a uniform edge alignment; if any other method is proposed, it shall

meet the approval of the Engineer before being used. Irregularities in the alignment of the outside edges and along the longitudinal joint shall be corrected by adding or removing HMA before the edges are rolled. Excess HMA deposited on the existing base, binder course, or surface course outside the limits of the lane being laid shall be removed immediately and disposed of as directed by the Engineer.

- (f) Segregation Control. Paving operations shall be conducted in a manner to prevent medium or high segregation.

Plant operations, hauling of the mix, paver operations, and the compacted mat shall be continually monitored for segregation.

The in-place HMA shall be evaluated daily for segregation according to the QC/QA document "Segregation Control of Hot-Mix Asphalt".

The Contractor's Annual Quality Control Plan or Addendum shall identify the individual(s) responsible for performing and documenting the daily evaluations. Quality Control Plans and Addendums for subsequent projects shall reflect the corrective actions taken, whether the corrective action was initiated by the Contractor or the Engineer.

- (g) Construction Joints. Transverse and longitudinal construction joints shall be constructed according to the following.

Joints between old and new pavements or between successive days' work shall be made so as to ensure thorough and continuous bond between the old and new mixtures.

- (1) Transverse Joints. The HMA shall be placed away from transverse construction joints.

Transverse construction joints in previously laid material may be constructed by cutting the material back for its full depth to expose a fresh surface. Where a wooden header is used at a construction joint, the cutting may be omitted provided the joint conforms to the specified thickness.

- (2) Longitudinal Joints. Unless prohibited by stage construction, any HMA lift shall be complete before construction of the subsequent lift. The longitudinal joint in all lifts shall be at the centerline of the pavement if the roadway comprises two lanes in width, or at lane width if the roadway is more than two lanes in width.

When stage construction prohibits the total completion of a particular lift, the longitudinal joint in one lift shall be offset from the longitudinal joint in the preceding lift by not less than 3 in. (75 mm). The longitudinal joint in the surface course shall be at the centerline of the pavement if the roadway comprises two lanes in width, or at lane width if the roadway is more than two lanes in width.

A notched wedge longitudinal joint shall be used between successive passes of HMA binder course that has a difference in elevation of greater than 2 in. (50 mm) between lanes on pavement that is open to traffic.

The notched wedge longitudinal joint shall consist of a 1 to 1 1/2 in. (25 to 38 mm) vertical notch at the lane line, a 9 to 12 in. (230 to 300 mm) wide uniform taper sloped toward and extending into the open lane, and a second 1 to 1 1/2 in. (25 to 38 mm) vertical notch at the outside edge.

The notched wedge longitudinal joint shall be formed by the strike off device on the paver. The wedge shall then be compacted by the joint roller.

When using a notched wedge joint, the bituminous material specified for the mainline prime coat shall be applied to the entire face of the longitudinal joint immediately prior to placing the adjacent lift of binder. The material shall be uniformly applied at a rate of 0.05 to 0.1 gal/sq yd (0.2 to 0.5 L/sq m).

406.07 Compaction. The HMA shall be compacted according to the following requirements.

- (a) Rollers. Immediately after each lift of level binder, binder, or surface course mixture is placed, each lift shall be compacted with equipment meeting the requirements listed in the following Table 1.

TABLE 1 - MINIMUM ROLLER REQUIREMENTS FOR HMA ^{4/}				
	Breakdown Roller (one of the following)	Intermediate Roller	Final Roller (one or more of the following)	Density Requirement
Level Binder: (When the density requirements of Article 406.05(c) do not apply.)	P ^{3/}	--	V _S , P, T _B , T _F , 3W	To the satisfaction of the Engineer.
Binder and Surface ^{1/}				
Level Binder ^{1/} : (When the density requirements of Article 406.05(c) apply.)	V _D , P, T _B , 3W	P ^{3/}	V _S , T _B , T _F	As specified in Articles: 1030.05(d)(3), (d)(4), and (d)(7).
Bridge Decks ^{2/}	T _B	--	T _F	As specified in Articles: 582.05 and 582.06.

1/ If the average delivery at the job site is 85 ton/hr (75 metric ton/hr) or less, any roller combination may be used provided it includes a steel wheeled roller and the required density and smoothness is obtained.

2/ One T_B may be used for both breakdown and final rolling on bridge decks 300 ft (90 m) or less in length, except when the air temperature is less than 60 °F (15 °C).

3/ A V_D roller may be used in lieu of the P roller on mixtures containing polymer modified asphalt binder.

4/ For mixture IL-4.75, a minimum of two T_B rollers and one T_F roller shall be provided. Both the T_B and T_F rollers shall be a minimum of 280 lb/in. (49 N/mm). P and V rollers will not be permitted.

EQUIPMENT DEFINITION

- V_s - Vibratory roller, static mode, minimum 125 lb/in. (2.2 kg/mm) of roller width. Maximum speed = 3 mph (5 km/h) or 264 ft/min (80 m/min). If the vibratory roller does not eliminate roller marks, its use shall be discontinued and a tandem roller, adequately ballasted to remove roller marks, shall be used.
- V_D - Vibratory roller, dynamic mode, operated at a speed to produce not less than 10 impacts/ft (30 impacts/m).
- P - Pneumatic-tired roller, max. speed 3 1/2 mph (5.5 km/h) or 308 ft/min (92 m/min). The pneumatic-tired roller shall have a minimum tire pressure of 80 psi (550kPa) and shall be equipped with heat retention shields. The self propelled pneumatic-tired roller shall develop a compression of not less than 300 lb (53 N) nor more than 500 lb (88 N) per in. (mm) of width of the tire tread in contact with the HMA surface.
- T_B - Tandem roller for breakdown rolling, 8 to 12 tons (7 to 11 metric tons), 250 to 400 lb/in. (44 to 70 N/mm) of roller width, max. speed = 3 1/2 mph (5.5 km/h) or 308 ft/min (92 m/min).
- T_F - Tandem roller for final rolling, 200 to 400 lb/in. (35 to 70 N/mm) of roller width with minimum roller width of 50 in. (1.25 m). Ballast shall be increased if roller marks are not eliminated. Ballast shall be decreased if the mat shoves or distorts.
- $3W$ - Three wheel roller, max. speed = 3 mph (5 km/h) or 264 ft/min (80 m/min), 300 to 400 lb/in. (53 to 70 N/mm) of roller width. The three-wheel roller shall weigh 10 to 12 tons (9 to 11 metric tons).

- (b) Rolling. When initial rolling causes undue displacement, haircracking, or checking in either the binder course or the surface course, the time of rolling will be adjusted by the Engineer to correct these conditions.

Rolling of the first lane of binder and surface course shall start longitudinally at the edge having the lower elevation and progress to the other edge, overlapping on successive trips to obtain uniform coverage. The roller shall not pass over an unprotected edge of the freshly laid HMA, unless directed by the Engineer. When directed by the Engineer, the edge shall be rolled with a pneumatic-tired roller.

When laying the HMA adjacent to a previously placed lane, the first pass of the roller shall be along the longitudinal joint on the fresh mixture with the compression wheel not more than 6 in. (150 mm) from the joint. The second pass of the roller shall overlap the longitudinal joint not more than 12 in. (300 mm) on the previously placed lane, after which the rolling shall proceed from the low side of the transverse slope to the high side, overlapping uniformly. Each stop shall be regulated to prevent trapping of water on the rolled surface. The steel-wheeled rollers shall be operated with the compression wheels toward the direction of paving.

The speed of the roller at all times shall be slow enough to avoid displacement of the HMA. If displacement occurs, it shall be corrected at once by raking and applying fresh HMA where required. To prevent adhesion of the HMA to the roller, the wheels shall be kept properly moistened without an excess of water.

Rolling of the binder and surface courses shall be continued until all roller marks are eliminated and the HMA is satisfactorily compacted. When required by the Engineer, the surface course shall be rolled diagonally in two directions with a tandem roller, the second rolling crossing the lines of the first, and, if the width of the pavement permits, it shall also be rolled at right angles to the centerline.

In all places inaccessible to the rollers, such as locations adjacent to curbs, gutters, headers, manholes, and similar structures, the required compaction shall be secured with tampers.

Any HMA that becomes loose, broken, mixed with foreign material, or is in any way defective shall be removed and replaced with fresh HMA and compacted to conform to the surrounding area.

- (c) Density. The density of the compacted HMA shall be according to Articles 1030.05(d)(3), (d)(4), and (d)(7).

406.08 Butt Joints. Butt joints shall be constructed according to the details shown on the plans. The surface removal shall be performed according to Section 440. Construction of butt joints shall not begin prior to beginning general operations on the project.

When butt joints are to be constructed under traffic, temporary ramps shall be constructed and maintained at both upstream and downstream ends of the surface

removal areas immediately upon completion of the surface removal operation. The temporary ramps shall be constructed by the following methods.

- (a) Temporary HMA Ramps. Temporary HMA ramps shall have a minimum taper rate of 1:40 (V:H). The HMA material used shall meet the approval of the Engineer. Cold-milled HMA tailings will not be acceptable.
- (b) Temporary Rubber Ramps. Temporary rubber ramps shall only be used on roadways with permanent posted speeds of 55 mph or less. The ramps shall have a minimum taper rate of 1:30 (V:H). The leading edge of the rubber ramp shall have a maximum thickness of 1/4 in. (6 mm) and the trailing edge shall match the height of the adjacent pavement \pm 1/4 in. (\pm 6 mm).

The rubber material shall be according to the following.

Property	Test Method	Requirement
Durometer Hardness, Shore A	ASTM D 2240	80 \pm 10
Tensile Strength	ASTM D 412	800 psi (5500 kPa) min.
Elongation, percent	ASTM D 412	100 min.
Specific Gravity	ASTM D 297	1.1-1.3
Brittleness	ASTM D 746	-40 °F (-40 °C)

The rubber ramps shall be installed according to the manufacturer's specifications and fastened with the anchors provided. Rubber ramps that fail to stay in place or create a traffic hazard shall be replaced immediately with temporary HMA ramps at the Contractor's expense.

The temporary ramps shall be removed just prior to placing the proposed surface course. If work is suspended for the winter season prior to completion of surface course construction, precut butt joints shall be filled to the elevation of the existing pavement surface with compacted HMA surface course or binder course.

406.09 Approaches, Intersections, and Entrances. The thickness of the HMA surface at the ends of the proposed resurfacing and adjacent to railroad grade crossings shall be diminished uniformly to a featheredge at a rate of 1:240 (V:H). At paved intersections, the HMA shall be feathered out in a distance of 10 ft (3 m), unless otherwise directed by the Engineer. At these locations, the thickness of the surface course shown on the plans shall be maintained to a point where the binder course has been reduced to 1 in. (25 mm) in thickness. Beyond this point, surface course only shall be used. At these locations where the HMA surface is diminished uniformly to a featheredge, the last 5 ft (1.5 m) shall receive an additional application of bituminous prime coat, just prior to placing the HMA.

Unpaved intersections and entrances shall be constructed as shown on the plans or designated by the Engineer. The existing surface shall be prepared according to Section 358 and receive an application of bituminous prime coat.

406.10 Multi-Lane Pavement Resurfacing. For multi-lane pavement resurfacing, the lift(s) of binder course shall be placed and compacted prior to start of

placement of the surface course mixture. When HMA shoulder resurfacing is not being constructed simultaneously with the mainline pavement, a HMA wedge at least 3 ft (1 m) wide shall be placed on the shoulder simultaneously with binder placement on the mainline pavement. The wedge shall be constructed according to the details shown on the plans or as directed by the Engineer.

406.11 Surface Tests. The completed surface course will be tested for smoothness in the wheel paths with a 16 ft (5 m) straightedge. Surface variations of the mainline pavement shall not exceed 3/16 in. (5 mm). Mainline pavement is defined as all pavement, except the following: ramps which will be posted for speeds of 40 mph (70 km/h) or less, acceleration and deceleration lanes, crossovers, side street turns, and other miscellaneous pavement surfaces as determined by the Engineer. In all areas other than mainline pavement, surface variations shall not exceed 3/8 in. (10 mm).

The smoothness test will not be performed on binder courses, but the Engineer reserves the right to require corrective measures when obvious surface variations are evident.

For each variation in the surface course that exceeds the maximum permissible specified above but is less than 3/4 in. (20 mm), a deduction will be made in the tonnage of surface course mixture measured for payment as specified in the following table.

Binder and/or Surface Course Plan Thickness, in. (mm)	Surface Course Mixture Deduction Per Variation, ton (metric ton)
(Existing Surface Not Reprofiled)	
2 3/4 (70) or more	2 (2)
Less than 2 3/4 (70)	1 (1)
(Existing Surface Reprofiled)	
All	2 (2)

In all cases where the variation in surface course equals or exceeds 3/4 in. (20 mm), the entire area affected shall be removed and replaced with fresh surface course mixture at the entire expense of the Contractor.

The Contractor shall furnish a 16 ft (5 m) straightedge and shall provide for its jobsite transportation at no additional cost to the Department.

406.12 Protection of Pavement. The Contractor shall protect all sections of newly compacted binder and surface courses from traffic until they have hardened to the satisfaction of the Engineer.

406.13 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirement for the use of contract quantities shall be according to 202.07(a).
- (b) Measured Quantities. Bituminous priming material will be measured for payment as specified in Section 1032. Water added to emulsified asphalt as

specified in Article 406.02 will be included in the quantities measured for payment.

Aggregate for covering prime coat will be measured for payment in tons (metric tons). The aggregate will be weighed on platform scales meeting the approval of the Engineer.

Mixture for cracks, joints and flangeways, leveling binder (machine method), leveling binder (hand method), binder course, and surface course mixtures will be measured for payment in tons (metric tons) on approved platform scales, surge bin scales, or surge bin hopper scales equipped with automatic printers as specified in Article 1102.01(a)(9). HMA produced by a batch-type mixing plant may be measured by batch weights only when surge or storage bins are not used. An occasional check to verify the accuracy of the batch weights or automatic printers, will be made by weighing full truck loads of the HMA on an approved platform scale at the plant or on a commercial scale approved by the Engineer. If it becomes apparent that the batch weights or automatic printers are not accurate in measuring the HMA, the scales and/or printers shall be repaired immediately. Quantities of materials wasted or disposed of in a manner not called for in the contract will be deducted from the final total measured quantities. The Contractor shall furnish a load ticket upon which is recorded the net weight of the HMA in each truck, as specified in Article 1102.01(a)(9). In addition, the load ticket shall have sufficient space for signatures, identification of the HMA, date of delivery, and any other data which the Engineer may require. The Contractor shall submit the load ticket to the Engineer at the work site when the truck arrives.

Mixture for cracks, joints, and flangeways, leveling binder (machine method), leveling binder (hand method), and binder course in excess of 103 percent of the quantity specified by the Engineer will not be measured for payment.

Surface course mixture in excess of 103 percent of the adjusted plan quantity will not be measured for payment. The adjusted plan quantity for surface course mixtures will be calculated as follows.

Adjusted Plan Quantity = C x quantity shown on the plans or as specified by the Engineer

$$\text{where } C = : \quad \text{English: } C = \frac{G_{mb} \times 46.8}{U} \quad \text{metric: } C = \frac{G_{mb} \times 24.99}{U}$$

and where: G_{mb} = average bulk specific gravity from approved mix design

U = unit weight of surface course shown on the plans in lb/sq yd/in. (kg/sq m/25 mm), used to estimate plan quantity

46.8 = English constant

24.99 = metric constant

If project circumstances warrant a new surface course mix design, the above equations shall be used to calculate the adjusted plan quantity for each mix design using its respective average bulk specific gravity.

Surface removal for butt joints will be measured for payment in place and the area computed in square yards (square meters).

Temporary ramps will be measured for payment in place and area computed in square yards (square meters).

When the option of placing HMA binder and surface course mixtures on shoulders is used, and shoulders at 6 ft (1.8 m) or less in width are placed simultaneously with the traffic lane as specified in Section 482, the quantity of HMA placed on the traffic lane will be limited to a calculated tonnage based upon actual mat width and length, plan thickness, or a revised thickness authorized by the Engineer, and design mix weight per inch (millimeter) of thickness. The difference between the total actual tonnage placed and the calculated tonnage used on the traffic lane will be measured and paid for as HMA shoulders according to Section 482.

When a HMA wedge is placed simultaneously with the binder course as specified in Article 406.10, the quantity of binder course placed on the traffic lane will be limited to 103 percent of the quantity specified by the Engineer. The difference between the total actual tonnage placed and 103 percent of the tonnage specified by the Engineer will be measured and paid for as HMA shoulders according to Section 482.

406.14 Basis of Payment. Prime Coat will be paid for at the contract unit price per gallon (liter) or per ton (metric ton) for BITUMINOUS MATERIALS (PRIME COAT), POLYMERIZED BITUMINOUS MATERIALS (PRIME COAT), and per ton (metric ton) for AGGREGATE (PRIME COAT).

The HMA surfacing will be paid for at the contract unit price per ton (metric ton) for MIXTURE FOR CRACKS, JOINTS, AND FLANGEWAYS; LEVELING BINDER (HAND METHOD), of the Ndesign specified; LEVELING BINDER (MACHINE METHOD) of the Ndesign specified; HOT-MIX ASPHALT BINDER COURSE, of the mixture composition and Ndesign specified; and HOT-MIX ASPHALT SURFACE COURSE, of the friction aggregate mixture and Ndesign specified.

The HMA surfacing in which polymer modified asphalt binders are required, will be paid for at the contract unit price per ton (metric ton); POLYMERIZED LEVELING BINDER (HAND METHOD), of the Ndesign specified; POLYMERIZED LEVELING BINDER (MACHINE METHOD), of the Ndesign specified; POLYMERIZED HOT-MIX ASPHALT BINDER COURSE, of the mixture composition and Ndesign specified; and POLYMERIZED HOT-MIX ASPHALT SURFACE COURSE, of the friction aggregate mixture and Ndesign specified.

Mixture IL-4.75 will be paid for at the contract unit price per ton (metric ton) for POLYMERIZED LEVELING BINDER (MACHINE METHOD), IL-4.75, N50; and POLYMERIZED HOT-MIX ASPHALT SURFACE COURSE, IL-4.75, N50.

Surface removal for butt joints will be paid for at the contract unit price per square yard (square meter) for HOT-MIX ASPHALT SURFACE REMOVAL - BUTT JOINT and PORTLAND CEMENT CONCRETE SURFACE REMOVAL - BUTT JOINT.

Temporary ramps will be paid for at the contract unit price per square yard (square meter) for TEMPORARY RAMP.

If an anti-stripping additive is required for any HMA, the cost of the additive will be paid for according to Article 109.04. The cost incurred in introducing the additive into the HMA will not be paid for separately, but shall be considered as included in the contract unit price bid for the HMA item involved. No additional compensation will be awarded to the Contractor because of reduced production rates associated with the addition of the additive.

If provided as a payment item, the preparation of base will be measured and paid for as specified in Section 358. If not provided as a payment item, the cost of the preparation of the base will be paid for according to Article 109.04.

Test strips will be evaluated for payment at the contract unit price per each for CONSTRUCTING TEST STRIP, according to the following.

- (a) If the HMA placed during the initial test strip is determined to be acceptable, the mixture and test strip will be paid at the contract unit prices.
- (b) If the HMA placed during the initial test strip (1) is determined to be unacceptable to remain in place by the Engineer, and (2) was not produced within the tolerances of the JMF, the initial mixture and test strip will not be paid for and shall be removed at the Contractor's expense. An additional test strip will be paid for in full, if produced within the JMF tolerances.
- (c) If the HMA placed during the initial test strip (1) is determined to be unacceptable to remain in place by the Engineer, and (2) was produced within the tolerances of the JMF, the mixture shall be removed. Removal will be paid for according to Article 109.04 of the Standard Specifications. This initial mixture and test strip will be paid for at the contract unit prices. The additional mixture will be paid for at the contract unit price, and any additional test strips will be paid for at one half the unit price of each test strip.
- (d) If the HMA placed during a test strip is determined to be acceptable to remain in place by the Engineer and the Engineer deems a new start-up is required for any reason, the initial mixture and test strip will be paid for at the contract unit prices. The additional mixture will be paid for at the contract unit price and any additional test strips will be paid for at one-half the unit price of each test strip.
- (e) If the Contractor requests and is granted approval for a mix design other than the initial approved HMA mix design, he/she shall construct a test strip for the new mix design at no additional cost to the Department.

SECTION 407. HOT-MIX ASPHALT PAVEMENT (FULL DEPTH)

407.01 Description. This work shall consist of constructing a full-depth hot-mix asphalt (HMA) pavement on a prepared subgrade.

407.02 Materials. Materials shall be according to Article 406.02, except as follows.

Item	Article/Section
(a) Bituminous Materials (Note 1)	1032
(b) Packaged Rapid Hardening Mortar or Concrete	1018

Note 1. The bituminous material for prime coat shall be RC-70, SS-1h, CSS-1h, SS-1hP, or CSS-1hP.

407.03 Equipment. Equipment shall be according to Article 406.03 and Article 1101.10.

Pavement thickness cores shall be taken utilizing an approved coring machine. The cores shall have a diameter of 2 in. (50 mm). The cores will be measured with a device supplied by the Department.

CONSTRUCTION REQUIREMENTS

407.04 General. HMA Pavement (Full-Depth) shall be constructed according to the applicable portions of Section 406 with binder and surface course mixtures as shown on the plans.

407.05 Subgrade. The subgrade shall be prepared according to Section 301, or Section 302 when specified, except Articles 301.05 and 301.06 will not apply.

407.06 Placing. Prior to placing the initial lift of the HMA binder course, all trimmings and other loose material shall be removed from the prepared subgrade.

The HMA shall be placed according to Article 406.06 and the following.

- (a) Each compacted lift of HMA shall be clean when the next lift is placed.
- (b) When directed by the Engineer, a bituminous prime coat shall be applied at a rate of 0.02 gal/sq yd (0.1 L/sq m).
- (c) The compacted thickness of the initial lift of binder course shall be 4 in. (100 mm). The compacted thickness of succeeding lifts shall meet the minimums specified in Article 406.06(d) but shall not exceed 4 in. (100 mm). If a vibrating roller is used for breakdown, the compacted thickness of binder lifts, excluding the top lift, may be increased to 6 in. (150 mm), provided the required density is obtained.

407.07 Pipe Underdrains. If pipe underdrains are to be constructed along the edges of the full-depth pavement, construction of the pipe underdrains shall not

be started until at least 9 1/2 in. (240 mm) of HMA binder course or the entire thickness of the full-depth pavement, whichever is the lesser, is in place. Material excavated from the trench for the underdrain shall not be deposited or windrowed on any portion of the full-depth pavement.

407.08 Hauling on the Partially Completed Full-Depth Pavement. Legally loaded trucks will be permitted on the partially completed full-depth HMA pavement only to deliver HMA mixture to the paver, provided the last lift has cooled a minimum of 12 hours. Hauling shall be limited to the distances shown in the following tables. The pavement surface temperature shall be measured using an infrared gun. The use of water to cool the pavement to permit hauling will not be allowed. The Contractor's traffic pattern shall minimize hauling on the partially completed pavement and shall vary across the width of the pavement such that "tracking" of vehicles, one directly behind the other, does not occur.

MAXIMUM HAULING DISTANCE FOR PAVEMENT SURFACE TEMPERATURE BELOW 105 °F (40 °C)				
Total In-Place Thickness Being Hauled On, in. (mm)	Thickness of Lift Being Placed			
	3 in. (75 mm) or less		More than 3 in. (75 mm)	
	Modified Soil Subgrade	Granular Subbase	Modified Soil Subgrade	Granular Subbase
3.0 to 4.0 (75 to 100)	0.75 miles (1200 m)	1.0 mile (1600 m)	0.50 miles (800 m)	0.75 miles (1200 m)
4.1 to 5.0 (101 to 125)	1.0 mile (1600 m)	1.5 miles (2400 m)	0.75 miles (1200 m)	1.0 mile (1600 m)
5.1 to 6.0 (126 to 150)	2.0 miles (3200 m)	2.5 miles (4000 m)	1.5 miles (2400 m)	2.0 miles (3200 m)
6.1 to 8.0 (151 to 200)	2.5 miles (4000 m)	3.0 miles (4800 m)	2.0 miles (3200 m)	2.5 miles (4000 m)
Over 8.0 (200)	No Restrictions			

MAXIMUM HAULING DISTANCE FOR PAVEMENT SURFACE TEMPERATURE OF 105 °F (40 °C) AND ABOVE				
Total In-Place Thickness Being Hauled On, in. (mm)	Thickness of Lift Being Placed			
	3 in. (75 mm) or less		More than 3 in. (75 mm)	
	Modified Soil Subgrade	Granular Subbase	Modified Soil Subgrade	Granular Subbase
3.0 to 4.0 (75 to 100)	0.50 miles (800 m)	0.75 miles (1200 m)	0.25 miles (400 m)	0.50 miles (800 m)
4.1 to 5.0 (101 to 125)	0.75 miles (1200 m)	1.0 mile (1600 m)	0.50 miles (800 m)	0.75 miles (1200 m)
5.1 to 6.0 (126 to 150)	1.0 mile (1600 m)	1.5 miles (2400 m)	0.75 miles (1200 m)	1.0 mile (1600 m)
6.1 to 8.0 (151 to 200)	2.0 miles (3200 m)	2.5 miles (4000 m)	1.5 miles (2400 m)	2.0 miles (3200 m)
Over 8.0 (200)	No Restrictions			

Permissive hauling on the partially completed pavement shall not relieve the Contractor of his/her responsibility for damage to the pavement. Any portion of the full-depth HMA pavement that is damaged by hauling shall be removed and replaced, or otherwise repaired to the satisfaction of the Engineer.

Crossovers used to transfer haul trucks from one roadway to the other shall be at least 1000 ft (300 m) apart and shall be constructed of material that will prevent tracking of dust or mud on the completed HMA lifts. The Contractor shall construct, maintain, and remove all crossovers.

407.09 Surface Tests. The finished surface of the pavement will be tested using a California Profilograph or an approved equivalent, or a 16 ft (5 m) straightedge as specified below. The Contractor shall remove all objects and debris from the pavement surface prior to the required profilograph or straightedge measurements.

- (a) 16 ft (5 m) Straightedge. Pavement surfaces listed in the following table will be tested in the wheel paths with a 16 ft (5 m) straightedge set to the tolerance specified.

Location	Tolerance
Ramps, Loops, and Climbing Lanes	1/4 in. (6 mm)
Mainline Gaps \leq 0.1 mile (160 m)	1/4 in. (6 mm)
Bridge Approaches	1/4 in. (6 mm)
Side Roads & Side Streets $>$ 600 ft (180 m) in length	1/4 in. (6 mm)
50 ft (15 m) from Bridge Approaches, Wideflange Beam Terminal Joints, Existing Pavement, or Mainline Gaps	1/4 in. (6 mm)
All curves \leq 1000 ft (300 m) radius including S.E. transitions	3/8 in. (10 mm)
Acceleration or Deceleration Lanes	3/8 in. (10 mm)
Side Streets \leq 600 ft (180 m) in length	3/8 in. (10 mm)
Turn Lanes, Storage Lanes, and Crossovers, etc.	3/8 in. (10 mm)
Intersections	3/8 in. (10 mm)

A 16 ft (5 m) straightedge set to a 3/16 in. (5 mm) tolerance will be used to test the mainline pavement in lieu of the California Profilograph where the posted speed, as determined by the contract signing requirements, is:

- (1) Less than or equal to 40 mph (70 km/h) or
- (2) Greater than 40 mph (70 km/h) with a net project length of less than 1 mile (1600 m).

Surface variations which exceed the above tolerances will be marked by the Engineer and shall be removed by the Contractor with an approved grinding device consisting of multiple saws. The use of a bush hammer or other impact devices will not be permitted.

- (b) Profilograph. Mainline pavement will be tested with a California Profilograph or approved equivalent. Mainline pavement is defined as all pavement, except that listed in the table located in (a) above and other miscellaneous pavement surfaces as determined by the Engineer. The profile will terminate 50 ft (15 m) from each wide flange beam terminal joint, bridge approach pavement, or existing pavement which is joined by the new pavement.

The Contractor shall furnish paving equipment and employ methods that produce a riding surface having a maximum profile index of 10 in./mile (160 mm/km) for any 0.1 mile (160 m) segment, except as provided for elsewhere. When starting up paving operations or after a long shutdown period, pavement surface will be tested the first several days with the profilograph as soon as the surface has cooled sufficiently to allow testing. For the purpose of surface tests, paving operations for HMA (Full-Depth) shall be interpreted as being concerned with the placement and compaction of the HMA surface course. Once the initial pavement smoothness, paving methods, and paving equipment are acceptable to the Engineer, daily profiles will be run during the next working day following placement of the pavement surface course. The Contractor may use his/her profilograph on other jobs simultaneously provided such use will not interfere with the necessary testing as outlined above and scheduling can be agreed to by the respective Resident Engineers involved.

When the contract does not require the Contractor to furnish a profilograph, the Department will furnish it. When the Contractor is required to furnish a profilograph, he/she shall also be responsible for its maintenance and jobsite transportation.

- (1) Profile Index and Price Adjustments. A daily Profile Index will be determined for each day's paving. Determination of the Profile Index will be according to Test Method No. California 526. A day's paving is defined as a minimum of 1000 ft (300 m) of paving placed in a single day. If less than 1000 ft (300 m) is paved, the day's production will be grouped with the subsequent day's production. If a profile Index of 15 in./mile (235 mm/km) is exceeded in any day's production, the initial testing procedures will be resumed until the index is less than 15 in./mile (235 mm/km).

On the first paving day, a profile up to 15 in./mile (235 mm/km) for any 0.1 mile (160 m) segment will be accepted without applicable Price Adjustment and the profile will be excluded from the average profile index determined for the project.

Pavement Profiles will be taken 3 ft (1 m) from and parallel to each edge for pavement placed at a 12 ft (3.6 m) width, or less. When pavement is placed at a greater width than 12 ft (3.6 m), the profile will be taken 3 ft (1 m) from and parallel to each edge and each side of the planned longitudinal joint. When the pavement being constructed is contiguous with an existing parallel pavement which was not constructed as a part of this contract, the profile parallel with the edge of pavement contiguous with the existing pavement will not be taken. The profile index for each 0.1 mile (160 m) section will be the average of the profiles taken.

Acceptance and pay adjustments for HMA (Full-Depth) will be based upon the smoothness of the final surface. Measurements on prior lifts are encouraged.

Price adjustments will be determined as follows.

- a. Evaluation as a Whole. When the average profile index for the entire mainline pavement is 0.5 in./mile (8 mm/km) or less and every 0.1 mile (160 m) section has a profile index of 10 in./mile (160 mm/km) or less, the pavement will be evaluated as a whole and the contract unit price will be adjusted according to Price Adjustment Schedule 1.

PRICE ADJUSTMENT SCHEDULE 1	
Profile Index for Entire Project in./mile (mm/km)	Percent of Contract Unit Price
0.20 (3) or less	103
Over 0.20 (3) to 0.25 (6)	102
Over 0.25 (6) to 0.50 (8)	101

- b. Evaluation per Each 0.1 mile (160 m) Section. When the requirements of paragraph a. above are not met, the pavement will be evaluated per each 0.1 mile (160 m) section and the contract unit price will be adjusted according to Price Adjustment Schedule 2 for that section.

PRICE ADJUSTMENT SCHEDULE 2	
Profile Index for Each 0.1 mile (160 m) Section, in./mile (mm/km)	Percent of Contract Unit Price
10 (160) or less	100
Over 10 (160) to 11 (175)	98
Over 11 (175) to 12 (190)	96
Over 12 (190) to 13 (205)	94
Over 13 (205) to 14 (220)	92
Over 14 (220) to 15 (235)	90
Over 15 (235)	Corrective work required ^{1/}

- 1/ When the Contractor chooses to grind the pavement, 90 percent of the contract unit price shall be the maximum amount of pay for that section of pavement. When the Contractor chooses to remove and replace the section, the Contractor will be paid the percent of the contract unit price which corresponds to the replaced section's final profile index.

The Contractor will not be allowed to perform corrective work to increase his/her percent of pay.

- (2) Corrective Work. All areas represented by high points having deviations in excess of 0.3 in. (8 mm) in 25 ft (8 m) shall be corrected with an approved grinding device consisting of multiple saws. The use of a bushhammer or other impact devices will not be permitted.

Each 0.1 mile (160 m) section of pavement with a profile index greater than 15 in./mile (235 mm/km) shall be either ground until the measured

profile index is less than or equal to 15 in./mile (235 mm/km) or removed and replaced at the Contractor's option.

On those 0.1 mile (160 m) pavement sections where corrective work is required, additional profilograph runs will be performed to verify that corrections have produced a profile index of 15 in./mile (235 mm/km) or less. If the initial profile index is less than 15 in./mile (235 mm/km), only the areas representing 0.3 in. (8 mm) deviations in 25 ft (8 m) will be reprofiled for correction verification.

All ground areas shall be neat, rectangular areas of uniform surface appearance bounded laterally by lane lines or edges of pavement. Determination of pavement thickness will be made after the removal of high spots.

407.10 Tolerance in Thickness. Determination of pavement thickness shall be performed after the pavement surface tests and corrective action have been completed according to Article 407.09. Pay adjustments made for pavement thickness will be in addition to and independent of those made for pavement smoothness. Pavement pay items that individually contain at least 1000 sq yd (840 sq m) of contiguous pavement shall be evaluated with the following exclusions: temporary pavements; variable width pavements; radius returns; short lengths of contiguous pavements less than 500 ft (125 m) in length; and constant width portions of turn lanes less than 500 ft (125 m) in length. Temporary pavements are defined as pavements constructed and removed under the same contract.

The method described in Article 407.10(a), shall be used except for those pavements constructed in areas where access to side streets and entrances necessitates construction in segments less than 1000 ft (300 m). The method described in Article 407.10(b) shall be used in areas where access to side streets and entrances necessitates construction in segments less than 1000 ft (300 m).

(a) **Percent Within Limits.** The percent within limits (PWL) method shall be as follows.

- (1) **Lots and Sublots.** The pavement will be divided into approximately equal lots of not more than 5000 ft (1500 m) in length. When the length of a continuous strip of pavement is 500 ft (150 m) or greater but less than 5000 ft (1500 m), these short lengths of pavement, ramps, turn lanes, and other short sections of continuous pavement will be grouped together to form lots approximately 5000 ft (1500 m) in length. Short segments between structures will be measured continuously with the structure segments omitted. Each lot will be subdivided into ten equal sublots. The width of a subplot and lot will be the width from the pavement edge to the adjacent lane line, from one lane line to the next, or between pavement edges for single-lane pavements.
- (2) **Cores.** Cores 2 in. (50 mm) in diameter shall be taken from the pavement by the Contractor, at locations selected by the Engineer. The exact location for each core will be selected at random, but will result in one core per subplot. Core locations will be specified prior to beginning the coring operations.

The Contractor and the Engineer shall witness the coring operations, as well as the measuring and recording of the cores. The cores will be measured with a device supplied by the Department immediately upon removal from the core bit and prior to moving to the next core location. Upon concurrence of the length, the core samples shall be disposed of according to Article 202.03.

Upon completion of each core, all water shall be removed from the hole and the hole then filled with a rapid hardening mortar or concrete. The material shall be mixed in a separate container, placed in the hole, consolidated by rodding, and struck-off flush with the adjacent pavement.

- (3) Deficient Sublot. When the length of the core in a sublot is deficient by more than ten percent of plan thickness, the Contractor may take three additional cores within that sublot at locations selected at random by the Engineer. If the Contractor chooses not to take additional cores, the pavement in that sublot shall be removed and replaced.

When the three additional cores are taken, the length of those cores will be averaged with the original core length. If the average shows the sublot to be deficient by ten percent or less, no additional action is necessary. If the average shows the sublot to be deficient by more than ten percent, the pavement in that sublot shall be removed and replaced; however, when requested in writing by the Contractor, the Engineer may permit in writing such deficient sublots to remain in place. For deficient sublots allowed to remain in place, additional lift(s) may be placed, at no additional cost to the Department, to bring the deficient pavement to plan thickness when the Engineer determines grade control conditions will permit such lift(s). The area(s) to be overlaid, material to be used, thickness(es) of the lift(s), and method of placement will be approved by the Engineer.

When a deficient sublot is removed and replaced, or additional lifts are placed, the corrected sublot shall be retested for thickness. The length of the new core taken in the sublot will be used in determining the PWL for the lot.

When a deficient sublot is left in place and no additional lift(s) are placed, no payment will be made for the deficient sublot. The length of the original core taken in the sublot will be used in determining the PWL for the lot.

- (4) Deficient Lot. After addressing deficient sublots, the PWL for each lot will be determined. When the PWL of a lot is 60 percent or less, the pavement in that lot shall be removed and replaced; however when requested in writing by the Contractor, the Engineer may permit in writing such deficient lots to remain in place. For deficient lots allowed to remain in place, additional lift(s) may be placed, at no additional cost to the Department, to bring the deficient pavement to plan thickness when the Engineer determines grade control conditions will permit such

lift(s). The area(s) to be overlaid, material to be used, thickness(es) of the lift(s), and method of placement will be approved by the Engineer.

When a deficient lot is removed and replaced, or additional lifts are placed, the corrected lot shall be retested for thickness. The PWL for the lot will then be recalculated based upon the new cores; however, the pay factor for the lot shall be a maximum of 100 percent.

When a deficient lot is left in place and no additional lift(s) are placed, the PWL for the lot will not be recalculated.

- (5) Right of Discovery. When the Engineer has reason to believe the random core selection process will not accurately represent the true conditions of the work, he/she may order additional cores. The additional cores shall be taken at specific locations determined by the Engineer. The Engineer will provide notice to the Contractor containing an explanation of the reasons for his/her action. The need for, and location of, additional cores will be determined prior to commencement of coring operations.

When the additional cores show the pavement to be deficient by more than ten percent of plan thickness, more additional cores shall be taken to determine the limits of the deficient pavement and that area shall be removed and replaced; however, when requested in writing by the Contractor, the Engineer may permit in writing such areas of deficient pavement to remain in place. The area of deficient pavement will be defined using the length between two acceptable cores and the full width of the subplot. An acceptable core is a core with a length of at least 90 percent of plan thickness.

For deficient areas allowed to remain in place, additional lift(s) may be placed, at no additional cost to the Department, to bring the deficient pavement to plan thickness when the Engineer determines grade control conditions will permit such lift(s). The area(s) to be overlaid, material to be used, thickness(es) of the lift(s), and method of placement will be approved by the Engineer.

When an area of deficient pavement is removed and replaced, or additional lifts are placed, the corrected pavement shall be retested for thickness.

When an area of deficient pavement is left in place, and no additional lift(s) are placed, no payment will be made for the deficient pavement.

When the additional cores show the pavement to be at least 90 percent of plan thickness, the additional cores will be paid for according to Article 109.04.

- (6) Profile Index Adjustment. After any area of pavement is removed and replaced or any additional lifts are placed, the corrected areas shall be retested for pavement smoothness and any necessary profile index

adjustments and/or corrections will be made based on these final profile readings prior to retesting for thickness.

- (7) Determination of PWL. The PWL for each lot will be determined as follows.

Definitions:

x_i	=	Individual values (core lengths) under consideration
n	=	Number of individual values under consideration (10 per lot)
\bar{x}	=	Average of the values under consideration
LSL	=	Lower Specification Limit (98% of plan thickness)
Q_L	=	Lower Quality Index
S	=	Sample Standard Deviation
PWL	=	Percent Within Limits

Determine \bar{x} for the lot to the nearest two decimal places.

Determine S for the lot to the nearest three decimal places using:

$$S = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} \quad \text{where } \sum (x_i - \bar{x})^2 = (x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + \dots + (x_{10} - \bar{x})^2$$

Determine Q_L for the lot to the nearest two decimal places using:

$$Q_L = \frac{(\bar{x} - LSL)}{S}$$

Determine PWL for the lot using the Q_L and the following table. For Q_L values less than zero the value shown in the table must be subtracted from 100 to obtain PWL.

- (8) Pay Factors. The pay factor (PF) for each lot will be determined, to the nearest two decimal places, using:

$$PF \text{ (in percent)} = 55 + 0.5 (PWL)$$

If \bar{x} for a lot is less than the plan thickness, the maximum PF for that lot shall be 100 percent.

- (9) Payment. Payment of incentive or disincentive for pay items subject to the PWL method will be calculated using:

$$\text{Payment} = (((TPF/100)-1) \times CUP) \times (TOTPAVT - DEFPAVT)$$

TPF	=	Total Pay Factor
CUP	=	Contract Unit Price
TOTPAVT	=	Area of Pavement Subject to Coring
DEFPAVT	=	Area of Deficient Pavement

The TPF for the pavement shall be the average of the PF for all the lots; however, the TPF shall not exceed 102 percent.

Area of Deficient pavement (DEFPAVT) is defined as an area of pavement represented by a subplot deficient by more than ten percent which is left in place with no additional thickness added.

Area of Pavement Subject to Coring (TOTPAVT) is defined as those pavement areas included in lots for pavement thickness determination.

PERCENT WITHIN LIMITS							
Quality Index (Q _L)*	Percent Within Limits (PWL)	Quality Index (Q _L)*	Percent Within Limits (PWL)	Quality Index (Q _L)*	Percent Within Limits (PWL)	Quality Index (Q _L)*	Percent Within Limits (PWL)
0.00	50.00	0.40	65.07	0.80	78.43	1.20	88.76
0.01	50.38	0.41	65.43	0.81	78.72	1.21	88.97
0.02	50.77	0.42	65.79	0.82	79.02	1.22	89.17
0.03	51.15	0.43	66.15	0.83	79.31	1.23	89.38
0.04	51.54	0.44	66.51	0.84	79.61	1.24	89.58
0.05	51.92	0.45	66.87	0.85	79.90	1.25	89.79
0.06	52.30	0.46	67.22	0.86	80.19	1.26	89.99
0.07	52.69	0.47	67.57	0.87	80.47	1.27	90.19
0.08	53.07	0.48	67.93	0.88	80.76	1.28	90.38
0.09	53.46	0.49	68.28	0.89	81.04	1.29	90.58
0.10	53.84	0.50	68.63	0.90	81.33	1.30	90.78
0.11	54.22	0.51	68.98	0.91	81.61	1.31	90.96
0.12	54.60	0.52	69.32	0.92	81.88	1.32	91.15
0.13	54.99	0.53	69.67	0.93	82.16	1.33	91.33
0.14	55.37	0.54	70.01	0.94	82.43	1.34	91.52
0.15	55.75	0.55	70.36	0.95	82.71	1.35	91.70
0.16	56.13	0.56	70.70	0.96	82.97	1.36	91.87
0.17	56.51	0.57	71.04	0.97	83.24	1.37	92.04
0.18	56.89	0.58	71.38	0.98	83.50	1.38	92.22
0.19	57.27	0.59	71.72	0.99	83.77	1.39	92.39
0.20	57.65	0.60	72.06	1.00	84.03	1.40	92.56
0.21	58.03	0.61	72.39	1.01	84.28	1.41	92.72
0.22	58.40	0.62	72.72	1.02	84.53	1.42	92.88
0.23	58.78	0.63	73.06	1.03	84.79	1.43	93.05
0.24	59.15	0.64	73.39	1.04	85.04	1.44	93.21
0.25	59.53	0.65	73.72	1.05	85.29	1.45	93.37
0.26	59.90	0.66	74.04	1.06	85.53	1.46	93.52
0.27	60.28	0.67	74.36	1.07	85.77	1.47	93.67
0.28	60.65	0.68	74.69	1.08	86.02	1.48	93.83
0.29	61.03	0.69	75.01	1.09	86.26	1.49	93.98
0.30	61.40	0.70	75.33	1.10	86.50	1.50	94.13
0.31	61.77	0.71	75.64	1.11	86.73	1.51	94.27
0.32	62.14	0.72	75.96	1.12	86.96	1.52	94.41
0.33	62.51	0.73	76.27	1.13	87.20	1.53	94.54
0.34	62.88	0.74	76.59	1.14	87.43	1.54	94.68
0.35	63.25	0.75	76.90	1.15	87.66	1.55	94.82
0.36	63.61	0.76	77.21	1.16	87.88	1.56	94.95
0.37	63.98	0.77	77.51	1.17	88.10	1.57	95.08
0.38	64.34	0.78	77.82	1.18	88.32	1.58	95.20
0.39	64.71	0.79	78.12	1.19	88.54	1.59	95.33

*For Q_L values less than zero, subtract the table value from 100 to obtain PWL

PERCENT WITHIN LIMITS (continued)					
Quality Index (Q _L)*	Percent Within Limits (PWL)	Quality Index (Q _L)*	Percent Within Limits (PWL)	Quality Index (Q _L)*	Percent Within Limits (PWL)
1.60	95.46	2.00	98.83	2.40	99.89
1.61	95.58	2.01	98.88	2.41	99.90
1.62	95.70	2.02	98.92	2.42	99.91
1.63	95.81	2.03	98.97	2.43	99.91
1.64	95.93	2.04	99.01	2.44	99.92
1.65	96.05	2.05	99.06	2.45	99.93
1.66	96.16	2.06	99.10	2.46	99.94
1.67	96.27	2.07	99.14	2.47	99.94
1.68	96.37	2.08	99.18	2.48	99.95
1.69	96.48	2.09	99.22	2.49	99.95
1.70	96.59	2.10	99.26	2.50	99.96
1.71	96.69	2.11	99.29	2.51	99.96
1.72	96.78	2.12	99.32	2.52	99.97
1.73	96.88	2.13	99.36	2.53	99.97
1.74	96.97	2.14	99.39	2.54	99.98
1.75	97.07	2.15	99.42	2.55	99.98
1.76	97.16	2.16	99.45	2.56	99.98
1.77	97.25	2.17	99.48	2.57	99.98
1.78	97.33	2.18	99.50	2.58	99.99
1.79	97.42	2.19	99.53	2.59	99.99
1.80	97.51	2.20	99.56	2.60	99.99
1.81	97.59	2.21	99.58	2.61	99.99
1.82	97.67	2.22	99.61	2.62	99.99
1.83	97.75	2.23	99.63	2.63	100.00
1.84	97.83	2.22	99.66	2.64	100.00
1.85	97.91	2.25	99.68	≥ 2.65	100.00
1.86	97.98	2.26	99.70		
1.87	98.05	2.27	99.72		
1.88	98.11	2.28	99.73		
1.89	98.18	2.29	99.75		
1.90	98.25	2.30	99.77	≥ 2.65	100.00
1.91	98.31	2.31	99.78		
1.92	98.37	2.32	99.80		
1.93	98.44	2.33	99.81		
1.94	98.50	2.34	99.83		
1.95	98.56	2.35	99.84		
1.96	98.61	2.36	99.85		
1.97	98.67	2.37	99.86		
1.98	98.72	2.38	99.87		
1.99	98.78	2.39	99.88		

*For Q_L values less than zero, subtract the table value from 100 to obtain PWL

(b) Minimum Thickness. The minimum thickness method shall be as follows.

- (1) Length of Units. The length of a unit will be a continuous strip of pavement 500 ft (150 m) in length.
- (2) Width of Units. The width of a unit will be the width from the pavement edge to the adjacent lane line, from one lane line to the next, or between pavement edges for single-lane pavements.
- (3) Thickness Measurements. Pavement thickness will be based on 2 in. (50 mm) diameter cores.

Cores shall be taken from the pavement by the Contractor at locations selected by the Engineer. When determining the thickness of a unit, one core shall be taken in each unit.

The Contractor and the Engineer shall witness the coring operations, as well as the measuring and recording of the cores. Core measurements will be determined immediately upon removal from the core bit and prior to moving to the next core location. Upon concurrence of the length, the core samples may be disposed of according to Article 202.03.

Upon completion of coring, all water shall be removed from the hole and the hole then filled with a rapid hardening mortar or concrete. The material shall be mixed in a separate container, placed in the hole, consolidated by rodding, and struck-off flush with the adjacent pavement.

- (4) Unit Deficient in Thickness. In considering any portion of the pavement that is deficient, the entire limits of the unit to be used in computing the deficiency or determining the remedial action required.
- (5) Thickness Equals or Exceeds Specified Thickness. When the thickness of a unit equals or exceeds the specified plan thickness, payment will be made at the contract unit price per square yard (square meter) for the specified thickness.
- (6) Thickness Deficient by Ten Percent or Less. When the thickness of a unit is less than the specified plan thickness by ten percent or less, a deficiency deduction will be assessed against payment for the item involved. The deficiency will be a percentage of the contract unit price as given in the following table.

Percent Deficiency (of Plan Thickness)	Percent Deduction (of Contract Unit Price)
0.0 to 2.0	0
2.1 to 3.0	20
3.1 to 4.0	28
4.1 to 5.0	32
5.1 to 7.5	43
7.6 to 10.0	50

- (7) Thickness Deficient by More than Ten Percent. When a core shows the pavement to be deficient by more than ten percent of plan thickness, additional cores shall be taken on each side of the deficient core, at stations selected by the Contractor and offsets selected by the Engineer, to determine the limits of the deficient pavement. No core shall be located within 5 ft (1.5 m) of a previous core obtained for thickness determination. The first acceptable core obtained on each side of a deficient core will be used to determine the length of the deficient pavement. An acceptable core is a core with a thickness of at least 90 percent of plan thickness. The area of deficient pavement will be defined using the length between two acceptable cores and the full width of the unit. The area of deficient pavement shall be removed and replaced; however, when requested in writing by the Contractor, the Engineer may permit in writing such areas of deficient pavement to remain in place. For deficient areas allowed to remain in place, additional lift(s) may be placed, at no additional cost to the Department, to bring the deficient pavement to plan thickness when the Engineer determines grade control conditions will permit such lift(s). The area(s) to be overlaid, material to be used, thickness(es) of the lift(s), and method of placement will be approved by the Engineer.

When an area of deficient pavement is removed and replaced, or additional lifts are placed, the corrected pavement shall be retested for thickness. The thickness of the new core will be used to determine the pay factor for the corrected area.

When an area of deficient pavement is left in place, and no additional lift(s) are placed, no payment will be made for the deficient pavement. In addition, an amount equal to two times the contract cost of the deficient pavement will be deducted from the compensation due the Contractor.

The thickness of the first acceptable core on each side of the core more than ten percent deficient will be used to determine any needed pay adjustments for the remaining areas on each side of the area deficient by more than ten percent. The pay adjustment will be determined according to Article 407.10(b)(6).

- (8) Right of Discovery. When the Engineer has reason to believe any core location does not accurately represent the true conditions of the work, he/she may order additional cores. These additional cores shall be taken at specific locations determined by the Engineer. The Engineer will provide notice to the Contractor containing an explanation of the reasons for his/her action.

When the additional cores show the pavement to be deficient by more than ten percent of plan thickness, the procedures outlined in Article 407.10(b)(7) shall be followed, except the Engineer will determine the additional core locations.

When the additional cores, ordered by the Engineer, show the pavement to be at least 90 percent of plan thickness, the additional cores will be paid for according to Article 109.04.

- (9) **Profile Index Adjustment.** After any area of pavement is removed and replaced or any additional lifts are added, the corrected areas shall be retested for pavement smoothness and any necessary profile index adjustments and/or corrections will be made based on these final profile readings prior to retesting for thickness.

407.11 Method of Measurement. This work will be measured for payment as follows.

- (a) **Contract Quantities.** The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) **Measured Quantities.** HMA Pavement (Full-Depth) will be measured for payment in place and the quantity computed in square yards (square meters). The width of measurement shall be the width of the top HMA lift as shown on the plans.

407.12 Basis of Payment. HMA Pavement (Full-Depth) will be paid for at the contract unit price per square yard (square meter) for HOT-MIX ASPHALT PAVEMENT (FULL-DEPTH), of the thickness specified.

When a prime coat is required, it will be paid for according to Article 109.04.

When the contract requires the Contractor to furnish a profilograph, the work will be paid for at the lump sum price for FURNISH PROFILOGRAPH.

SECTION 408. INCIDENTAL HOT-MIX ASPHALT SURFACING

408.01 Description. This work shall consist of constructing a hot-mix asphalt (HMA) surface on a prepared base.

408.02 Materials. Materials shall be according to Article 406.02.

Mixture composition IL-9.5, C or D, shall be used. Mixture composition IL-12.5, C or D, may be used subject to the lift thickness requirements of Article 406.06(d).

CONSTRUCTION REQUIREMENTS

408.03 General. The base shall be prepared according to Section 358.

Where incidental HMA surfacing will be subject to vehicular traffic, the base shall be primed according to Article 406.05(b).

The HMA may be spread and finished by approved hand methods or a spreading and finishing machine approved by the Engineer.

The HMA which will be subjected to vehicular traffic shall be compacted to the satisfaction of the Engineer with a tandem roller or vibratory roller. The HMA not subjected to traffic shall be compacted to the satisfaction of the Engineer.

408.04 Method of Measurement. Bituminous priming material and aggregate for covering the prime coat will be measured for payment according to Article 406.13.

Incidental HMA surfacing will be measured for payment in tons (metric tons) according to Article 406.13. Aprons placed with extendible screeds during mainline paving will be considered an integral part of the mainline paving and will not be measured for payment as incidental HMA surfacing.

Preparation of base will be measured according to Article 358.06.

408.05 Basis of Payment. This work will be paid for at the contract unit price per ton (metric ton) or per gallon (liter) for BITUMINOUS MATERIALS (PRIME COAT), at the contract unit price per ton (metric ton) for AGGREGATE (PRIME COAT), and at the contract unit price per ton (metric ton) for INCIDENTAL HOT-MIX ASPHALT SURFACING.

Preparation of base will be paid for according to Article 358.07.

PORTLAND CEMENT CONCRETE PAVEMENTS AND SIDEWALKS

SECTION 420. PORTLAND CEMENT CONCRETE PAVEMENT

420.01 Description. This work shall consist of a pavement composed of portland cement concrete with or without reinforcement, constructed on a prepared subgrade, or subbase, with or without forms.

420.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Concrete Reinforcement Bars, Fabric and Strand (Note 1)	1006.10
(c) Pavement Longitudinal Metal Joints, Dowel Bars, and Dowel Bar Assembly	1006.11
(d) Poured Joint Sealer	1050.01, 1050.02
(e) Preformed Expansion Joint Fillers	1051.09
(f) Protective Coat	1023.01
(g) Nonshrink Grout	1024.02
(h) Chemical Adhesive Resin System	1027.01
(i) Preformed Elastomeric Joint Seals for Pavement	1053.01
(j) Packaged Rapid Hardening Mortar or Concrete	1018

Note 1. All tie bars, reinforcement bars, and chair supports used in bridge approach pavement shall be epoxy coated.

420.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Forms	1103.05
(b) Formless Paver	1103.16
(c) Mechanical Concrete Spreader	1103.12
(d) Finishing Machine	1103.13
(e) Mechanical Longitudinal Float	1103.15
(f) Concrete Finisher Float	1103.14
(g) Vibrators	1103.12
(h) Miscellaneous Equipment	1103.17
(i) Pavement Surface Test Equipment	1101.10
(j) Coring Machine (Note 1)	

Note 1. Pavement thickness cores shall be taken utilizing an approved coring machine. The cores shall have a diameter of 2 in. (50 mm). The cores will be measured with a device supplied by the Department.

CONSTRUCTION REQUIREMENTS

420.04 Preparation of Subgrade or Subbase. The subgrade or subbase shall be prepared according to Sections 301, except Articles 301.05 and 301.06 shall not apply, and Sections 302, 310, 311, or 312 shall apply as appropriate. The minimum width of the prepared subgrade or subbase shall be as shown on the plans.

420.05 Joints. Joints in the pavement shall be constructed as shown on the plans and as follows.

- (a) Longitudinal Sawed Joint. The tie bars shall be placed perpendicular to the joint by approved mechanical equipment or shall be rigidly supported on support pins or approved joint assemblies.

Longitudinal sawed joints shall be formed by cutting the surface of the pavement by means of an approved concrete saw to the depth and width shown on the plans. A suitable guide shall be used to assure cutting of the longitudinal joint on the true line as shown on the plans.

Sawing of the longitudinal joint shall commence as soon as the concrete has hardened sufficiently to permit sawing without excessive raveling, usually four to 24 hours. All joints shall be sawed before uncontrolled shrinkage cracking takes place. If necessary, the sawing operations shall be carried on both during the day and night regardless of weather conditions.

Curing covering shall be removed from the pavement only at the location where a joint is to be cut. Only sufficient covering shall be removed to provide the necessary room for working at the location of the joint. As soon as the joint has been cut, the covering shall be replaced. In no case shall the top surface and edges of the pavement be left unprotected for a period of more than 30 minutes.

When multiple lane pavement is being placed in more than one operation, all required sawing of longitudinal joints shall be performed on the pavement in place before additional lanes are constructed.

Sawing of a longitudinal joint shall be continuous across all transverse joints. Whenever sawing is discontinued, the cut shall terminate at a transverse joint. Water supply equipment for the sawing operations may be permitted on the pavement provided individual axle loads are less than 4000 lb (18 kN). The applied wheel loads shall be at least 6 ft (1.8 m) from the pavement edge.

- (b) Longitudinal Construction Joint. The tie bars shall be installed in preformed or drilled holes along the vertical edge of the first lane placed. The tie bars shall be installed with an approved nonshrink grout or chemical adhesive providing a minimum pull-out strength as follows.

Bar Size	Minimum Pull-Out Strength
No. 6 (No. 19)	11,000 lb (49 kN)
No. 8 (No. 25)	19,750 lb (88 kN)

Holes shall be blown clean and dry prior to placing the grout or adhesive. If compressed air is used, the pneumatic tool lubricator shall be bypassed and a filter installed on the discharge valve to keep water and oil out of the lines. The installation shall be with methods and tools conforming to the grout or adhesive manufacturer's recommendations. The Contractor shall load test five percent of the first 500 tie bars installed. No further installation will be allowed until the initial five percent testing has been completed and approval to continue installation has been given by the Engineer. Testing will be required for 0.5 percent of the bars installed after the initial 500. For each bar that fails to pass the minimum requirements, two more bars selected by the Engineer shall be tested. Each bar that fails to meet the minimum load requirement shall be reinstalled and retested. The equipment and method used for testing shall meet the requirements of ASTM E 488. All tests shall be performed within 72 hours of installation. The tie bars shall be installed and approved before concrete is placed in the adjacent lane.

In lieu of the above, the tie bar may be formed in place provided the bar length is increased to 30 in. (750 mm), is maintained in the proper location, and the bar is straight.

The sealant reservoir shall be formed either by sawing after the concrete has set according to Article 420.05(a) or by hand tools when the concrete is in a plastic state.

- (c) Transverse Contraction Joints. Transverse contraction joints shall consist of planes of weakness created by sawing grooves in the surface of the pavement and shall include load transfer devices consisting of dowel bars supported on an approved dowel bar assembly. Transverse contraction joints shall be according to the following.

- (1) Planes of Weakness. Planes of weakness shall be created by sawing grooves in the surface of the pavement, of the dimensions and at the spacing and lines shown on the plans, with an approved concrete saw.

Sawing of the joint shall commence as soon as the concrete has hardened sufficiently to permit sawing without excessive raveling, usually four to 24 hours. All joints shall be sawed to the depth shown on the plans before uncontrolled shrinkage cracking takes place. If necessary, the sawing operations shall be carried on both during the day and night, regardless of weather conditions.

Curing covering shall be removed from the pavement only at the location where a joint is to be cut. Only sufficient covering shall be removed to provide the necessary room for working at the location of the joint. As soon as the joint has been cut, the covering shall be replaced. In no case shall the top surface and edges of the pavement be left unprotected for a period of more than 30 minutes.

Water may be sprayed on the saw blade during the cutting. A suitable stationary guide shall be used to prevent side swaying of the machine to ensure that the cut will be straight. Water shall be used, if necessary, to thoroughly clean the joint. All extraneous material, including free water, shall be removed from the joint opening by means of an air jet.

When uncontrolled cracking occurs in the pavement slab, the pavement will be evaluated for acceptance according to the following.

- a. General Conditions. No section of pavement less than 6 ft (1.8 m) in length will be allowed to remain in place. The Department will provide drawings and specification of repair procedures to the Contractor. If extreme conditions exist which make it impractical to prevent erratic cracking by early sawing, the contraction joint groove shall be formed in a manner approved by the Engineer prior to initial set of the concrete.
- b. Crack within Joint Area. The sawing of any joint shall be omitted if an uncontrolled crack occurs within 3 in. (75 mm) of either side of the joint prior to the time of sawing. Sawing shall be discontinued when a crack develops ahead of the saw. Uncontrolled cracks within this 3 in. (75 mm) limit will be considered an acceptable joint.
- c. Crack on One Side of Joint. If an uncontrolled crack develops on one side of the contraction joint, more than 3 in. (75 mm) from the joint and less than 6 ft (1.8 m) from the same joint, a minimum of 6 ft (1.8 m) of pavement removal and replacement will be required.
- d. Crack on Both Sides of Joint. If cracking occurs on both sides of the joint, more than 3 in. (75 mm) from the joint, the dowel bar assembly and a minimum of 3 ft (1 m) of pavement each side of the joint shall be removed and replaced.

- e. Crack in Mid-Panel Area. If an uncontrolled crack develops on one side of the contraction joint in the mid panel area between 6 ft (1.8 m) from the joint and the midpoint of the panel, the entire panel shall be replaced on that side of the joint within the lane containing the cracking.
- (2) Dowel Bar Assemblies. Dowel bar assemblies shall be installed at right angles to the centerline of the pavement with the dowel bars parallel to the proposed pavement surface and to each other.

The assembly shall act as a rigid unit with each component securely held in position relative to the other members of the assembly. The entire assembly shall be held securely in place by means of nails which shall penetrate the stabilized subbase. At least ten nails shall be used for each 10, 11, or 12 ft (3, 3.3, or 3.6 m) section of assembly. Bearing plates shall be punched to receive the nails. When bearing plates are omitted on stabilized subbase, other methods for securing the assembly with nails shall be provided.

Metal stakes shall be used instead of nails, with soil or granular subbase. The stakes shall loop over or attach to the top parallel spacer bar of the assembly and penetrate the subgrade or subbase at least 12 in. (300 mm).

All shipping tie wires shall be cut after the assembly is secured in place. At the location of each dowel bar assembly, the subgrade or subbase shall be reshaped and re-tamped when necessary.

Prior to placing concrete, any deviation of the dowel bars from the correct horizontal or vertical alignment greater than 1/8 in. in 12 in. (3 mm in 300 mm) shall be corrected and a light coating of oil shall be uniformly applied to the dowel bars.

Care shall be exercised in depositing the concrete at the dowel bar assemblies so that the horizontal and vertical alignment will be retained.

- (d) Transverse Expansion Joints. Transverse expansion joints shall consist of preformed expansion joint filler and a dowel bar assembly.

The concrete on either side of the transverse expansion joint shall be placed in two separate operations with a suitable header to form the first pour. The first pour shall cure at least 12 hours before the second pour is started.

The dowel bar assembly shall be installed according to Article 420.05(c)(2) and the following.

- (1) After the construction header is removed, plastic expansion caps shall be installed on the exposed end of each dowel bar.
- (2) The plastic expansion caps shall be installed after the dowel bars are oiled and the joint filler has been installed. The caps shall fit snugly on the bar and the closed end shall be watertight. A minimum expansion

gap of 2 in. (50 mm) between the end of the dowel bar and the end of the cap shall be provided.

The preformed expansion joint filler shall be shaped to the subgrade or subbase. Preformed expansion joint filler shall be furnished in lengths equal to the pavement width or equal to the width of one lane. The preformed expansion joint filler shall be held in a vertical position. An approved installing bar, or other device, shall be used if required to secure preformed expansion joint filler at the proper grade and alignment during placing and finishing of the concrete. The horizontal alignment of the finished joint shall be within 1/4 in. (6 mm) from a straight line. When preformed expansion joint fillers are assembled in sections, there shall be no offsets between adjacent units and it shall be continuous from form to form.

The transverse expansion joint shall be free of concrete anywhere within the expansion space.

- (e) **Transverse Construction Joints.** Transverse construction joints shall be constructed when there is an interruption of more than 30 minutes in the concreting operations. The transverse construction joint shall be formed by means of a suitable header, accurately set and securely held in place in a plane perpendicular to the surface of the pavement.

When the pavement is constructed with transverse contraction joints at 15 ft (5 m) spacings, the transverse construction joints shall be placed at contraction joint locations.

When the pavement is constructed with pavement fabric reinforcement, any transverse construction joint shall be at least 10 ft (3.0 m) from a contraction joint. If insufficient concrete has been mixed at the time of interruption to form a slab extending at least 10 ft (3.0 m) beyond the last contraction joint, the excess concrete back to the last preceding joint shall be removed and disposed of as directed by the Engineer and the construction joint shall be constructed as a contraction joint.

The pavement area adjacent to both sides of a transverse construction joint shall receive additional consolidation from hand vibrators inserted into the concrete and the surface shall be refinished. These areas shall extend a minimum of 5 ft (1.5 m) from the joint.

420.06 Forms and Form Setting. Prior to the start of paving, forms shall be in place to accommodate at least one day's paving. The forms shall be supported for the full length and width of the form line by either the subgrade or subbase. If required by the Engineer, the subbase or subgrade shall be tamped under the form line. The alignment of the form line shall be within a tolerance of $\pm 1/4$ in. (± 6 mm) with the plan edge of pavement. The elevation of the form shall be the plan elevation of the edge of pavement. Minor intermittent deviations in the subgrade or subbase elevation may be corrected, without the use of shims or wedges, by placing compacted granular or subbase material in 1/2 in. (13 mm) lifts or less for low areas. High areas may be corrected by tamping or trimming as required. The minimum form height shall equal the plan pavement thickness. Form heights exceeding the

pavement thickness may be used provided the forms are set and maintained at the plan elevation.

420.07 Placing. Concrete shall be mixed, placed or finished when the natural light is sufficient, unless an adequate and approved artificial lighting system is operated. Concrete shall not be placed on soft, muddy, or frozen subgrade or subbase; nor when the subgrade is frozen under permanent adjacent pavement.

The Contractor will be required to have materials available at all times for the protection of the edges and surface of the unhardened concrete. Such protective materials shall consist of standard metal forms or wood planks having a nominal thickness of not less than 1 in. (25 mm) and a nominal width of not less than the thickness of the pavement at its edge for the protection of the pavement edges, for slip form paving, and covering material such as polyethylene sheeting for the protection of the surface of all pavements.

When rain appears imminent, all paving operations shall stop sufficiently in advance to place forms against the sides of the pavement, when applicable, and to cover the surface of the unhardened concrete with protective covering.

Unhardened concrete shall be covered immediately to protect the surface against the effects of rain. Once covered, the unhardened concrete that is rained on shall not be uncovered to rework or refinish the surface. Pavement that is rained on prior to the completion of the Type A or Type B final finish shall be removed and replaced, unless in the opinion of the Engineer the pavement surface can be corrected by grinding. Pavement rained on after the completion of the final finish will be evaluated by the Engineer for acceptance.

The concrete shall be unloaded into a mechanical concrete spreader and deposited uniformly across the subgrade or subbase as close as possible to its final position. When required, hand spreading shall be accomplished with shovels.

Paving shall be continuous between transverse joint locations shown on the plans. Transverse joint assemblies shall be protected from displacement or damage during the placement and consolidation of the concrete.

When approved in writing by the Engineer, pavements in excess of 24 ft (7.2 m) or more in width may be constructed full width in a single operation.

Where concrete is to be placed adjoining a previously constructed lane of pavement, and mechanical equipment will be operated upon the previously constructed lane of pavement, the use of that lane of pavement shall be according to Article 701.17(c)(5), except for protective coat and pavement cleaning.

Should any concrete materials fall on or be worked into the surface of a completed slab, those materials shall be removed immediately by approved methods. When workers walk in freshly mixed concrete, they shall have clean boots or shoes, without earth or foreign substances.

420.08 Placement of Reinforcement. When reinforced concrete pavement is placed in two layers, the entire width of the bottom lift shall be struck off to such length and depth that the sheet of fabric or bar mat may be laid full length on the

concrete in its final position without further manipulation. Bends or kinks in individual wires, or other irregularities, shall be corrected before the sheet is laid in the pavement. The reinforcement shall then be placed directly upon the concrete, after which the top layer of the concrete shall be placed, struck off and screeded. Any portion of the bottom layer of concrete which has been placed more than 20 minutes without being covered with the top layer shall be removed and replaced with freshly mixed concrete. When reinforced concrete is placed in one layer, the reinforcement shall be positioned on steel chair supports according to Article 421.04(a).

The pavement reinforcement shall be placed such that the reinforcement in the completed pavement will be at the location shown on the plans with a placement tolerance for individual bars or individual wires of ± 1 in. (± 25 mm) horizontally and vertically.

Reinforcing steel shall be free from dirt, oil, paint, grease, or other materials which could impair bond with the concrete. All laps between sheets shall be held firmly together by wire or clips spaced 4 ft (1.2 m) or less apart.

420.09 Strike Off, Consolidation, Finishing, Longitudinal Floating, Straightedging, Edging, and Final Finish. Following placement, the concrete shall be struck off to conform to the cross section shown on the plans and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement will be at the elevation shown on the plans.

The sequence of operations shall be strike off, consolidation, finishing, longitudinal floating, straightedging, edging, and final finish according to the following.

- (a) Strike Off, Consolidation, and Finishing. Strike off, consolidation, and finishing shall be according to the following.
 - (1) Vibratory Method. After the concrete has been struck off, the concrete shall be vibrated for the full width and depth of the concrete pavement with a surface pan type vibrator or internal vibrator avoiding contact with a joint assembly, the grade, or side forms. The maximum time of concrete vibration at any one location shall be 10 seconds. The Contractor shall have a satisfactory tachometer available for checking the operating frequency of the vibrating elements.

As soon as the concrete has been spread and consolidated, it shall be finished by an approved finishing machine. The tops of the forms shall be kept clean by an effective device attached to the machine and the travel of the machine on the forms shall be maintained true without lift, wobbling, or other variations tending to affect a uniform finish. If the rate of depositing concrete is in excess of the amount which the finishing machine can strike off, consolidate, and finish, a second finishing machine shall be provided and used.

- (2) Hand Finishing. Hand finishing methods will be permitted only in the event of breakdown of the mechanical equipment. Hand methods may be used to strike off, consolidate, and finish the concrete already deposited on the grade when the breakdown occurs.

- (3) Vibrating Screed. An approved vibrating screed may be used to strike off, consolidate, and finish variable width pavement, pavement less than 10 ft (3 m) in uniform width, and paving gaps at driveways, intersections, etc. The vibration shall be shut off whenever forward motion of the screed is stopped.

In operation, the vibrating screed shall be moved forward on the forms, moving always in the direction in which the work is progressing and so manipulated that neither end is raised from the side forms during the striking off process. If necessary, this shall be repeated until the surface is of uniform texture, true to grade and cross section, and free from porous areas.

- (b) Longitudinal Float Method. The longitudinal float method shall be used on all mainline pavements with a posted speed limit of 40 mph or more. This method is optional for other pavement construction. After the concrete has been struck off, consolidated, and finished, it shall be further smoothed and trued, by means of an approved float, using one of the following methods.

- (1) Mechanical Longitudinal Float Method. The forward speed shall be adjusted so that the float will lap the distance specified by the Engineer on each transverse trip. The float shall pass over each area of pavement at least two times, without excessive operation over a given area. Excess water or soupy material shall be wasted over the side on each pass.
- (2) Concrete Finisher Float Method. Excessively wet mortar shall be wasted over the side on each pass.
- (3) Hand Method. This method may be used for all mainline pavements with a posted speed limit of less than 40 mph or in an emergency. The 10 ft (3 m), hand-operated, longitudinal float shall be used parallel to the road centerline and passed gradually from one side of the pavement to the other to fill depressions or cut down high areas. Movement ahead along the centerline of the pavement shall be in successive advances of 5 ft (1.5 m) or less. Any excess mortar shall be wasted over the side forms on each pass. Floating shall continue until the entire surface is found to be free from variations and the slab conforms to the required grade and cross section.

If necessary, following one of the preceding methods of floating, long handled floats having blades at least 3 ft (900 mm) in length and 6 in. (150 mm) in width may be used to smooth and fill in open-textured areas in the pavement, but shall not be used to float the entire surface of the pavement in lieu of, or supplementing one of the preceding methods of floating.

- (c) Straightedge Testing and Surface Correction. After the floating has been completed, but while the concrete is still plastic, the surface of the concrete shall be tested for trueness with a 10 ft (3 m) straightedge. The straightedge shall be held in contact with the surface in successive positions parallel to the pavement centerline and the whole area gone over from one side of the

slab to the other, advancing along the pavement in successive stages of 1/2 the length of the straightedge or less. Any depressions found shall be immediately filled with freshly mixed concrete, struck off, consolidated and refinished. High areas shall be cut down and refinished. Special attention shall be given to assure that the surface across joints meets the requirements for smoothness. Straightedge testing of the surface shall continue until the entire surface is found to be free from variations from the straightedge, and the slab conforms to the required grade and cross section.

When the hand method using a 10 ft (3 m) longitudinal float is permitted and surface corrections made as specified in Article 420.09(b), straightedge testing may be eliminated.

- (d) Edging. After longitudinal floating, straightedging, and before the final finish, the edges of the pavement shall be carefully finished with an edging tool having a radius of not more than 1/4 in. (6 mm) and the pavement edge left smooth and true to line.
- (e) Final Finish. Type A final finish shall be used unless Type B is specified.
 - (1) Type A. Type A final finish shall be obtained by the use of a carpet drag composed of an artificial turf approved by the Engineer followed immediately by a mechanically operated metal comb transverse grooving device.

The artificial turf shall be made of molded polyethylene with synthetic turf blades approximately 0.85 in. (20 mm) long and contain approximately 7,200 individual blades per 1 sq ft (0.1 sq m). The artificial turf shall be suitably attached to an approved device that will permit control of the time and rate of texturing. The artificial turf carpet shall be full pavement width and of sufficient size that during the finishing operation, approximately 2 ft (600 mm) of carpet parallel to the pavement centerline will be in contact with the pavement surface. The drag shall be operated in a longitudinal direction so as to produce a uniform appearing finish meeting the approval of the Engineer. If necessary for maintaining intimate contact with the pavement surface, the carpet may be weighted.

The metal comb shall consist of a single line of tempered spring steel tines variably spaced as shown in the table below and securely mounted in a suitable head. The tines shall be flat and of a size and stiffness sufficient to produce a groove of the specified dimensions in the plastic concrete without tearing of the pavement edge or surface. The mechanically operated metal comb shall be attached to an exclusive piece of equipment which is mechanically self-propelled and capable of traversing the entire pavement width being placed in a single pass. The artificial turf carpet drag may be attached to this piece of equipment provided a surface texture is produced satisfactory to the Engineer. The tining device shall be operated so as to produce a pattern of grooves, 1/8 to 3/16 in. (3 to 5 mm) deep and 1/10 to 1/8 in. (2.5 to 3.2 mm) wide across the pavement. The tining device shall be operated at a 1:6 skew across the pavement for facilities with a posted

speed limit of 55 mph or greater. The tining pattern shall not overlap or leave gaps between successive passes. No other operation will be permitted with this equipment. Separate passes will be required for the turf dragging operation and the tining operation.

Center to Center Spacings of Metal Comb Tines in. (mm) (read spacings left to right)				
1 5/16 (34)	1 7/16 (36)	1 7/8 (47)	2 1/8 (54)	1 7/8 (48)
1 11/16 (43)	1 1/4 (32)	1 1/4 (31)	1 1/16 (27)	1 7/16 (36)
1 1/8 (29)	1 13/16 (46)	13/16 (21)	1 11/16 (43)	7/8 (23)
1 5/8 (42)	2 1/16 (52)	15/16 (24)	11/16 (18)	1 1/8 (28)
1 9/16 (40)	1 5/16 (34)	1 1/16 (27)	1 (26)	1 (25)
1 1/16 (27)	13/16 (20)	1 7/16 (37)	1 1/2 (38)	2 1/16 (52)
2 (51)	1 3/4 (45)	1 7/16 (37)	1 11/16 (43)	2 1/16 (53)
1 1/16 (27)	1 7/16 (37)	1 5/8 (42)	1 5/8 (41)	1 1/8 (29)
1 11/16 (43)	1 3/4 (45)	1 3/4 (44)	1 3/16 (30)	1 7/16 (37)
1 5/16 (33)	1 9/16 (40)	1 1/8 (28)	1 1/4 (31)	1 15/16 (50)
1 5/16 (34)	1 3/4 (45)	13/16 (20)	1 3/4 (45)	1 15/16 (50)
2 1/16 (53)	2 (51)	1 1/8 (29)	1 (25)	11/16 (18)
2 1/16 (53)	11/16 (18)	1 1/2 (38)	2 (51)	1 9/16 (40)
11/16 (17)	1 15/16 (49)	1 15/16 (50)	1 9/16 (39)	2 (51)
1 7/16 (36)	1 7/16 (36)	1 1/2 (38)	1 13/16 (46)	1 1/8 (29)
1 1/2 (38)	1 15/16 (50)	15/16 (24)	1 5/16 (33)	

Hand tining or tining with a mechanically operated comb combined with the curing equipment specified in Article 1101.09 will be permitted where the Specifications permit hand finishing or vibratory screeds, one lane construction up to 16 ft (5 m) wide, gaps, projects with a net length of 1/2 mile (800 m) or less, and where the production rate on any paving day will be less than 1,500 cu yd (1200 cu m) per day. A foot bridge shall be provided for the hand tining operation for all pavement over 12 ft (3.6 m) wide, unless it can be demonstrated to the satisfaction of the Engineer that an alternate texturing operation produces satisfactory results.

- (2) Type B. Type B final finish shall be obtained by the use of a single artificial turf drag. The artificial turf shall conform and be operated according to the requirements for Type A finish, except this device shall be attached to a separate piece of equipment used expressly for the texturing operation.

420.10 Surface Tests. The surface of the finished pavement will be tested according to Article 407.09 and the following.

- (a) Initial Profilograph Testing. Testing with a profilograph for the first several days of paving following initial start up or after a long shutdown period will be performed as soon as the concrete has cured sufficiently to permit the testing.

(b) Price Adjustments. Price adjustments will be determined as follows.

- (1) Evaluation as a Whole. When the average profile index for the entire mainline pavement is 4.25 in./mile (67 mm/km) or less and every 0.1 mile (160 m) section has a profile index of 10 in./mile (160 mm/km) or less, the pavement will be evaluated as a whole and the contract unit price will be adjusted according to Price Adjustment Schedule 1.

PRICE ADJUSTMENT SCHEDULE 1	
Profile Index for Entire Project in./mile (mm/km)	Percent of Contract Unit Price
2.25 (36) or less	103
Over 2.25 (36) to 3.25 (53)	102
Over 3.25 (53) to 4.25 (67)	101

- (2) Evaluation per Each 0.1 mile (160 m) Section. When the requirements of paragraph (1) above are not met, the pavement will be evaluated per each 0.1 mile (160 m) section and the contract unit price will be adjusted according to Price Adjustment Schedule 2 for that section.

PRICE ADJUSTMENT SCHEDULE 2	
Profile Index for Each 0.1 mile (160 m) Section, in./mile (mm/km)	Percent of Contract Unit Price
10 (160) or less	100
Over 10 (160) to 11 (175)	98
Over 11 (175) to 12 (190)	96
Over 12 (190) to 13 (205)	94
Over 13 (205) to 14 (220)	92
Over 14 (220) to 15 (235)	90
Over 15 (235)	Corrective work required ^{1/}

- 1/ When the Contractor chooses to grind the pavement, 90 percent of the contract unit price shall be the maximum amount of pay for that section of pavement. When the Contractor chooses to remove and replace the section, the Contractor will be paid the percent of the contract unit price which corresponds to the replaced section's final profile index.

The Contractor will not be allowed to perform corrective work to increase his/her percent of pay.

Membrane curing damaged during the testing operations shall be repaired by the Contractor as directed by the Engineer at no additional cost to the Department.

On all areas where corrective grinding is done a protective coat according to Article 420.18 shall be applied at no additional cost to the Department.

Curing and protective covers, if used, shall be removed from the pavement for the required profilograph and straightedge measurements and properly replaced when the testing is completed according to Article 1020.13(b).

420.11 Removing Forms. Forms may be removed from freshly placed concrete which has set for at least 12 hours, except auxiliary forms used temporarily in widened areas. Forms shall be removed carefully avoiding damage to the pavement. After the forms have been removed, the sides of the slab shall be cured as outlined in one of the methods indicated in Article 1020.13.

Any honeycombed or porous areas shall be corrected as directed by the Engineer. Effective surface drainage shall be provided and maintained to prevent the accumulation of water along the edges of the pavement. Underwash along the edges shall be prevented, where grades are such as to cause this action, by placing earth against the edges to the full height of the slab.

420.12 Sealing Joints. Joints shall be sealed, as shown on the plans, before the pavement is opened to traffic, including construction traffic, and as soon after the curing period as feasible. Poured joint sealing material shall be placed when the air temperature in the shade is 50 °F (10 °C) or higher, unless approved by the Engineer.

Just prior to sealing, each joint shall be thoroughly cleaned of all foreign material, including membrane curing compound, and the joint faces shall be clean and surface dry when the seal is applied. Material for seal applied hot shall be stirred during heating to prevent localized overheating. The sealing material shall be applied to each joint opening according to the details shown on the plans or as directed by the Engineer, without spilling on the exposed concrete surfaces.

Any excess material on the surface of the concrete pavement shall be removed immediately and the pavement surface cleaned. The use of sand or similar material as a cover for the seal will not be permitted.

When dry sand is to be placed on the joint filler prior to sealing expansion joints with a hot-poured joint sealer, the sand shall be FA1 or FA2, Class A quality.

420.13 Opening to Traffic. The road shall be opened to traffic according to Article 701.17(c)(5).

420.14 Slip Form Method. At the option of the Contractor, slip form paving methods (formless paver), according to the following, may be used to perform the strike off, consolidation and finishing requirements of Article 420.09(a).

- (a) All paving equipment, including the spreader, paver, float, texturing machine, and curing machine shall ride on the stabilized subbase. The subbase shall be constructed to a width 6 in. (150 mm) wider than the width from outside-to-outside of the slip form paver's tracks at no additional cost to the Department.
- (b) The operations of placing, spreading, consolidating, and finishing shall be a continuous operation as much as possible. Starting and stopping of the paver shall be kept to a minimum.

- (c) The surface of the completed pavement shall be within the tolerance specified in Article 420.10, except that a tolerance will be permitted for edge slump, exclusive of edge rounding.

Uplift of the outer edge of slip-formed pavement shall be prevented. When uplift occurs, it shall be corrected before the concrete has hardened to allow for cross slope drainage. The paving operations will be stopped if operational adjustments fail to correct the uplift.

Edge slump will be measured by placing a 4 ft (1.2 m) straightedge perpendicular to the centerline of pavement and taking the vertical measurement at the edge of the completed pavement where the normal edge rounding begins. The following edge slump tolerances will be allowed.

- (1) Edge slump of the concrete pavement, exclusive of edge rounding, may vary up to 1/2 in. (13 mm) at locations where no additional concrete work is to be constructed immediately adjacent to the pavement being placed. Edge slump will be tested as soon as practical after paving operations begin. Any edge settlement in excess of 1/2 in. (13 mm) shall be corrected before the concrete has hardened. When edge settlements in excess of 1/2 in. (13 mm) persist, paving will be suspended and operational corrections shall be made before the Engineer will permit the resumption of paving. If the Contractor consistently fails to construct pavement within these specified tolerances, the use of slip form methods will be discontinued and the pavement shall be placed by means of conventional forms.
- (2) Edge slump of the concrete pavement of 1/4 in. (6 mm) or less shall be allowed at locations where additional concrete work (widening, ramps, additional lanes, shoulders, curb and gutter, etc.) is to be constructed immediately adjacent to the pavement being placed. The Contractor shall correct any edge settlement in these areas before the concrete has hardened.

If the concrete has hardened, edge slump shall be corrected by removing no less than 10 ft (3 m) in length of defective pavement full depth and replacing the pavement as part of the adjacent widening, ramps, additional lanes, shoulders, curb and gutter, etc.

All pavement removed for edge slump shall be sawed full depth longitudinally for a width of 1 ft (300 mm) or less. The transverse saw cuts and reinforcement replacement shall be according to Section 442 applicable to the pavement design being repaired. The pavement shall be carefully removed and No. 8 (No. 25) reinforcement bars 24 in. (600 mm) long shall be grouted in place in holes drilled at mid-depth on 30 in. (750 mm) centers along the pavement edge.

When variations in the edge of pavement are greater than 1 ft (300 mm) in width, a full lane width shall be removed. All full lane width removal and replacement shall be done according to Section 442 applicable to the pavement design being repaired and shall be at least 10 ft (3 m) in length.

If edge slump is a continuous problem in areas contiguous to adjacent concrete work, the concrete shall be placed and finished either as required for standard paving methods or by use of false forms placed adjacent to the slip formed pavement edge. The false forms shall be of sufficient thickness to maintain the proper shape and continuity of the form line and will be approved by the Engineer. Bracing of the forms shall be such that there will always be 10 ft (3 m) or less of unbraced false forms. False forms shall remain in place for at least 90 minutes, or for a longer period of time as directed by the Engineer when their removal may cause damage to the adjacent concrete.

420.15 Tolerance in Thickness. Determination of pavement thickness, computation of thickness, and requirements relative to deficient thickness shall be according to Article 407.10, except for the following.

- (a) Width of Sublots and Lots, or Units. The width of a subplot and lot, or unit, shall be the width from the pavement edge to the adjacent longitudinal joint, from one longitudinal joint to the next, or between pavement edges where there is no longitudinal joint.
- (b) Additional Lift(s). The option of correcting deficient pavement with additional lift(s) shall not apply.

420.16 Bridge Approach Pavement, Shoulder Pavement, and Connectors. These pavements shall be constructed according to the details shown on the plans. The subbase granular material shall be according to Section 311. Reinforcement bars shall be placed according to Article 421.04(a) and lapped 24 bar diameters. The preformed elastomeric joint seal shall be installed according to Article 520.06. When the Contractor, with the approval of the Engineer, elects to reduce the width of pours as shown on the plans, the shoulder pavement may be struck off and consolidated using a vibratory screed approved by the Engineer.

When the bridge approach pavement connector is specified to be flexible pavement, it shall be constructed according to Section 407.

420.17 Adjacent to Railroad Grade Crossing. Portland cement concrete pavement adjacent to railroad grade crossings shall be constructed according to the details shown on the plans, except that when the mainline portland cement concrete pavement thickness is greater than 10 in. (250 mm), the thickness of the slab adjacent to the railroad crossing shall be increased to the same thickness as the mainline.

The No. 7 (No. 22) reinforcement bars in the slab adjacent to the railroad crossing shall be lapped a minimum of 26 in. (650 mm). A longitudinal construction joint will be permitted in lieu of the sawed longitudinal joint when stage construction is used.

The hot-mix asphalt (HMA) plug shall be constructed with mixture composition IL-19.0 binder; or IL-12.5 or IL-9.5 surface according to Section 1030. The mixture shall be placed and compacted to the satisfaction of the Engineer.

420.18 Protective Coat Application. When pavement is constructed after November 1 and it will be opened to traffic prior to the following April 15, or when directed by the Engineer, a protective coat shall be applied to the surface of the pavement and appurtenances, when the concrete is at least 14 days old and before the pavement is marked and opened to traffic.

Before the protective coat is applied, the concrete surface shall have at least a 48-hour drying period since the last rain and shall be cleaned to remove all oil, grime, and loose particles which would prevent the mixture from penetrating the concrete.

The protective coat shall consist of two applications of the mixture and each application shall be at a rate of 50 sq yd/gal (11 sq m/L) or less.

The protective coat shall be sprayed on the surface with a mechanical spraying machine which will perform the work in a satisfactory manner. The spray nozzles shall be within 18 in. (450 mm) of the concrete or as directed by the Engineer. The interior of the distributor tank shall be thoroughly cleaned prior to placing the protective coat therein. Unless otherwise directed by the Engineer, the temperature of the concrete and air shall be 40 °F (4 °C) or higher at the time of application.

The second application of the protective coat shall be made when, in the opinion of the Engineer, the concrete has regained its dry appearance.

Traffic shall be prohibited from the area until the concrete has regained its dry appearance.

If an application of sand is required by the Engineer for blotter material, it will be paid for according to Article 109.04.

420.19 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Portland cement concrete pavement will be measured for payment in place and the area computed in square yards (square meters). The length will be measured along the centerline of the surface of each roadway or ramp. The width will be the width of pavement as shown on the plans.

Bridge approach pavement, bridge approach shoulder pavement, and bridge approach pavement connectors will be measured for payment in place and the area computed in square yards (square meters). The length will be measured along the centerline of the surface of each pavement. The width will be the width of pavement as shown on the plans. A deduction will be made for the area displaced by an inlet. No measurement will be made for the approach footing.

Pavement fabric will be measured for payment in place and the area computed in square yards (square meters). The measured area will be the same as the area of the concrete pavement in which the pavement fabric is installed.

Art. 420.19 Continuously Reinforced Portland Cement Concrete Pavement

The HMA plug used adjacent to a railroad grade crossing will be measured for payment according to Article 408.04.

The areas upon which the protective coat is applied, except where corrective grinding has been performed, will be measured for payment in place and the area computed in square yards (square meters).

420.20 Basis of Payment. This work will be paid for at the contract unit price per square yard (square meter) for PORTLAND CEMENT CONCRETE PAVEMENT, HIGH-EARLY-STRENGTH PORTLAND CEMENT CONCRETE PAVEMENT, and PORTLAND CEMENT CONCRETE PAVEMENT (JOINTED), of the thickness specified; and at the contract unit price per square yard (square meter) for BRIDGE APPROACH PAVEMENT, PORTLAND CEMENT CONCRETE BRIDGE APPROACH SHOULDER PAVEMENT, BRIDGE APPROACH PAVEMENT CONNECTOR (PORTLAND CEMENT CONCRETE), and BRIDGE APPROACH PAVEMENT CONNECTOR (FLEXIBLE).

Pavement fabric will be paid for at the contract unit price per square yard (square meter) for PAVEMENT FABRIC.

The HMA plug used adjacent to a railroad grade crossing will be paid for according to Article 408.05.

When the contract requires the Contractor to furnish a profilograph, the work will be paid for according to Article 407.12.

Protective coat will be paid for at the contract unit price per square yard (square meter) for PROTECTIVE COAT.

Removing and replacing curing and protective cover, when required, will be paid for according to Article 109.04.

SECTION 421. CONTINUOUSLY REINFORCED PORTLAND CEMENT CONCRETE PAVEMENT

421.01 Description. This work shall consist of constructing a continuously reinforced portland cement concrete pavement on a prepared subgrade or subbase.

421.02 Materials. Materials shall be according to Article 420.02. Wide flange beams shall be according to Article 1006.04 and be galvanized according to AASHTO M 111.

421.03 Equipment. Equipment shall be according to Article 420.03.

CONSTRUCTION REQUIREMENTS

421.04 General. Continuously reinforced concrete pavement shall be according to Articles 420.04 through 420.18 and the following.

- (a) **Placement of Reinforcement.** The pavement reinforcement shall be placed such that the reinforcement in the completed pavement will be at the location shown on the plans with a placement tolerance for individual bars of ± 1 in. (± 25 mm) horizontally and vertically.

Reinforcement bars shall be tied securely together. The minimum length of longitudinal bars shall be 30 ft (9 m), except as required to establish the lap arrangement selected.

During the placement of portland cement concrete, the Engineer will check the depth and lateral placement of the pavement reinforcement at such times and in such places as the Engineer may elect.

Pavement reinforcement shall be supported on steel chair supports at the depth below the pavement surface as shown on the plans. The Contractor shall submit prints of shop drawings showing details of chair supports and their spacing to the Engineer and obtain the Engineer's approval before any fabrication is begun.

The chair supports shall possess the necessary rigidity and be spaced at intervals close enough to hold the reinforcement at the proper depth and position. However, the spacing of the chair supports shall not exceed 3 ft (900 mm) transversely or 4 ft (1.2 m) longitudinally. The chair supports shall be fabricated with sand plates unless the steel chair supports are fabricated using the transverse bar and have two continuous subbase bearing members attached to the upright supports. Wire size for the bearing member shall be W7 or larger.

Pavement reinforcement bars shall be assembled by fastening the longitudinal bars to the transverse bars, without welding, using wire, clips, or other acceptable methods meeting the approval of the Engineer. The size and spacing of the bars shall be as shown on the plans.

- (b) **Joints and Concrete Lug End Anchorages.** The longitudinal and transverse joints and lug end anchorages shall be constructed as specified in the contract according to Article 420.05 with the following exceptions.
 - (1) **Longitudinal Sawed Joints.** The tie bars in longitudinal sawed joints shall be positioned on the prepared subbase prior to concrete placement and shall either be supported on approved assemblies or securely tied to the underside of the longitudinal bars of the pavement reinforcement.
 - (2) **Transverse Construction Joints.** Transverse construction joints shall be made at the end of each day or when an interruption in the concreting operation of 30 minutes or more occurs, provided the length of pavement laid from the last joint is 12 ft (4 m) or more and the distance

Art. 421.04 Continuously Reinforced Portland Cement Concrete Pavement

from the construction joint to the nearest bar-lap is at least 3 1/2 ft (1.1 m).

The transverse construction joint shall be formed by means of a suitable split header board conforming to the cross section of the pavement, accurately set and securely held in place in a plane perpendicular to the surface of the pavement. The pavement reinforcement bars shall extend continuously through the split in the header board and shall be supported beyond the joint by steel chair supports. The header board shall be kept clean without oil. Excess mortar material accumulated at the front of the paver shall be wasted and not incorporated into the pavement at the joint. Before paving operations are resumed, the header board shall be removed, any concrete or mortar that may have leaked through the holes or split in the header shall be chipped from the face of the joint and removed, all surplus concrete on the subgrade or subbase shall be cleared away, and any irregularities in the subgrade or subbase shall be corrected. The fresh concrete shall be deposited directly against the old and shall be consolidated with a hand vibrator inserted into the concrete and worked along the entire length of the joint. Transverse construction joints shall not be edged or sealed.

The pavement areas adjacent to both sides of a transverse construction joint shall receive additional consolidation from hand vibrators inserted into the concrete and the surface shall be refinished. These areas shall extend at least 10 ft (3 m) from the joint.

- (3) Transverse Terminal Joint. When specified, transverse terminal joints shall be constructed at the ends of a construction section according to the details shown on the plans. The concrete shall be either Class SI concrete or Class PV concrete. The pad shall be constructed to the same slope and cross section as the pavement and the entire top surface shall be given a smooth finish with a steel trowel. The concrete pad shall be completed and cured as specified in Article 1020.13 before the pavement and remainder of the transverse terminal joint is constructed.
- (4) Wide Flange Beam Terminal Joint. The sleeper slab shall be constructed of either Class SI concrete or Class PV concrete. The sleeper slab shall be constructed to the same slope and cross section as the pavement. The top surface of the sleeper slab shall be given a smooth finish with a steel trowel on the pavement side of the steel beam and a rough finish on the terminal joint side. The sleeper slab shall be cured according to Article 1020.13(a)(1)(2)(3)(5).

The optional adjustable chairs for the beams may be uncoated steel. When used, the chairs shall be at 6 ft (1.8 m) centers, beginning 3 ft (900 mm) from the end of the beam.

The concrete in the groove on the expansion side of the wide flange shall be carefully finished across the top and at the edges of the pavement to facilitate unrestrained pavement expansion.

- (5) Lug End Anchorages. The lugs shall be constructed in a trench without forms. Excavation for the trench shall be to the minimum dimensions shown on the plans. The lugs and the concrete pad above the lugs shall be constructed of either Class SI concrete or Class PV concrete and shall be cured according to Article 1020.13(a)(1)(2)(3)(5). The surface of the concrete pad shall be finished rough and shall be free of any dust, dirt, or other foreign material at the time the continuously reinforced concrete pavement is placed.

421.05 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Continuously reinforced portland cement concrete pavement will be measured for payment in place and the area computed in square yards (square meters). The width will be the width of pavement as shown on the plans.

Reinforcement bars will be measured for payment in square yards (square meters). The quantity of reinforcement bars will be the computed square yards (square meters) of surface area of the pavement in which the pavement reinforcement is installed.

The pavement surfaces upon which the protective coat is applied, except where corrective grinding has been performed, will be measured for payment in place and the areas computed in square yards (square meters).

421.06 Basis of Payment. This work will be paid for at the contract unit price per square yard (square meter) for CONTINUOUSLY REINFORCED PORTLAND CEMENT CONCRETE PAVEMENT and CONTINUOUSLY REINFORCED HIGH-EARLY-STRENGTH PORTLAND CEMENT CONCRETE PAVEMENT, of the thickness specified.

Reinforcement bars will be paid for at the contract unit price per square yard (square meter) for PAVEMENT REINFORCEMENT.

Wide flange beam terminal joints will be paid for at the contract unit price per each for WIDE FLANGE BEAM TERMINAL JOINT COMPLETE, of the pavement width specified.

Lug anchor systems will be paid for at the contract unit price per each for LUG SYSTEM COMPLETE, of the pavement width specified.

Transverse terminal joints will be paid for at the contract unit price per each for TRANSVERSE TERMINAL JOINT COMPLETE, of the pavement width specified.

Protective coat will be paid for at the contract unit price per square yard (square meter) for PROTECTIVE COAT.

Removing and replacing curing and protective cover, if required, will be paid for according to Article 109.04.

When the contract requires the Contractor to furnish a profilograph, the work will be paid for according to Article 407.12.

SECTION 422. PORTLAND CEMENT CONCRETE RAILROAD CROSSING

422.01 Description. This work shall consist of constructing a cast-in-place portland cement concrete railroad crossing constructed in two courses on a prepared subgrade.

The removal and replacement of ballast, rails, ties, tie plates, and fastenings; the surfacing and lining of track to true line and grade; and the furnishing and placing of the inner guardrails will be executed by others without charge to the Contractor.

422.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Reinforcement Bars	1006.10
(b) Portland Cement Concrete	1020
(c) Bituminous Materials	1032
(d) Protective Coat	1023
(e) Grout	1024.01

422.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Miscellaneous Equipment	1103.17

CONSTRUCTION REQUIREMENTS

422.04 Cooperation. The Contractor shall cooperate with the Railroad in order to eliminate undue delays to railroad traffic.

422.05 Subgrade Preparation. After the Railroad has removed or blocked up the existing rails and ties, and has removed and replaced the ballast, the subgrade shall be compacted to a uniform density throughout, true to grade and cross section.

422.06 Forms and Form Setting. Side forms shall be lumber of 2 in. (50 mm) nominal thickness or greater, or steel of equal rigidity. They shall be held securely in place by stakes or braces with the top edges true to line and grade.

422.07 Placing and Finishing. The subgrade shall be moistened just before the concrete is placed. While the tracks are blocked up or removed, the concrete for the lower slab shall be placed in successive batches for the entire width of the slab, consolidated with a hand vibrator, and struck off with floats and trowels. The final troweling shall be done with a steel trowel leaving a smooth, even surface. After the crossties have been reset and aligned, and before the Railroad is allowed to relay the track in its final position, one coat of liquid asphalt (RC-70) shall be applied to the top

of the base slab. The concrete in the upper portion or top slab shall then be placed in successive batches for the entire width of the slab, consolidated with a hand vibrator, struck off with floats and trowels, edged, and given a broom finish.

422.08 Adjustments. In order to secure an even track surface, it may be necessary to correct for variations in thickness of the cross-ties by one of the following methods.

- (a) Place the base slab approximately 1/2 in. (13 mm) lower than shown on the plans and provide a cement grout between the top of the base slab and the bottom of the ties. The grout mixture shall be one part cement and two parts sand mixed with water.
- (b) The ties shall be placed as soon as practicable after the placing of the 8 in. (200 mm) base slab and the elevation adjusted as the ties are laid in the plastic concrete.

422.09 Bituminous Filler for Rails and Flangeways. The bituminous material used to fill in around the rails and form the flangeways shall be a cold-lay sand-bituminous mixture meeting the requirements of the Engineer.

The cold-lay bituminous material used as the filler around the rails shall be laid only when the contact surfaces are dry and the air temperature is 40 °F (5 °C) or higher. Care shall be taken to prevent the bituminous mixture from becoming mixed with foreign materials. The contact surfaces of the rail and concrete shall be painted with a thin, uniform coating of liquid asphalt (RC-70) just before the bituminous cold-lay mixture is placed. The mixture shall be tamped thoroughly into place to the elevation shown on the plans or as directed by the Engineer.

422.10 Protective Coat. Protective coat shall be applied to the top slab according to Article 420.18.

422.11 Backfill. After the concrete has been cured, the spaces along the edges of the crossing shall be backfilled to the required elevation with approved granular material. The material shall be compacted and the surface neatly trimmed or graded.

422.12 Disposal of Surplus Material. Surplus or waste material resulting from the crossing construction operations shall be disposed of according to Article 202.03.

422.13 Method of Measurement. This work will be measured for payment in place and the area computed in square yards (square meters).

Reinforcement bars will be measured for payment in pounds (kilograms) according to Article 508.07.

Protective Coat will be measured for payment according to Article 420.19.

422.14 Basis of Payment. This work will be paid for at the contract unit price per square yard (square meter) for PORTLAND CEMENT CONCRETE RAILROAD CROSSING.

Reinforcement will be paid for according to Article 508.08.

Protective Coat will be paid for according to Article 420.20.

SECTION 423. PORTLAND CEMENT CONCRETE DRIVEWAY PAVEMENT

423.01 Description. This work shall consist of constructing portland cement concrete driveway pavement on a prepared subgrade.

423.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Preformed Expansion Joint Fillers	1051

423.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Miscellaneous Equipment	1103.17

CONSTRUCTION REQUIREMENTS

423.04 Subgrade Preparation. The subgrade shall be tamped or rolled until thoroughly compacted and at the proper line and grade as shown on the plans.

423.05 Forms. Side forms shall be of lumber of not less than 2 in. (50 mm) thickness or of steel of equal rigidity. They shall be held securely in place by stakes or braces, with the top edges true to line and grade.

423.06 Placing and Finishing. The subgrade shall be moistened just before the concrete is placed. The concrete shall be placed in successive batches for the entire width of the slab, struck-off, consolidated and finished to a true and even surface with a vibratory screed. Areas which are inaccessible to the vibratory screed method may be consolidated with a hand vibrator and struck off and finished by hand methods.

After strike-off, consolidation and finishing, the concrete shall be further smoothed by a hand-operated longitudinal float or a long-handled float.

After the water sheen has disappeared, the surface shall be given a broom finish. The broom shall be drawn across the driveway at right angles to the edges of the driveway, with adjacent strokes slightly overlapping, producing a uniform, slightly roughened surface with parallel broom marks.

The surface shall be divided by grooves constructed in the plastic concrete at 10 ft (3 m) maximum intervals both transversely and longitudinally, unless otherwise directed by the Engineer. These grooves shall extend to 1/4 the depth of the driveway, shall be not less than 1/8 in. (3 mm) nor more than 1/4 in. (6 mm) in width,

and shall be edged with an edging tool having a 1/4 in. (6 mm) radius. The edges of the slabs shall be edged as described above.

Tie bars will not be required in construction joints; however the joints shall be edged as described above.

423.07 Expansion Joints. At points where the proposed driveway pavement occupies the entire space between the concrete curb or combination concrete curb and gutter and an adjacent building, permanent structure, existing driveway or other similar obstruction, 1 in (25 mm) preformed expansion joint filler shall be placed between the driveway pavement and the obstruction. The expansion joint filler shall extend the entire depth of the driveway.

423.08 Backfill. After the concrete has been cured, the spaces along the edges of the driveway pavement shall be backfilled to the required elevation with approved material. The material shall then be compacted, and the surface neatly graded.

423.09 Disposal of Surplus Material. Surplus or waste material resulting from the driveway construction operations shall be disposed of according to Article 202.03.

423.10 Method of Measurement. This work will be measured for payment in place and the area computed in square yards (square meters).

Earth excavation will be measured for payment according to Article 202.07.

423.11 Basis of Payment. This work will be paid for at the contract unit price per square yard (square meter) for PORTLAND CEMENT CONCRETE DRIVEWAY PAVEMENT, of the thickness specified.

Earth excavation required will be paid for according to Article 202.08.

SECTION 424. PORTLAND CEMENT CONCRETE SIDEWALK

424.01 Description. This work shall consist of constructing portland cement concrete sidewalk and sidewalk accessibility ramps on a prepared subgrade. This work does not include sidewalk that is integrally a part of a structure.

424.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Preformed Expansion Joint Fillers	1051

424.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Miscellaneous Equipment	1103.17

CONSTRUCTION REQUIREMENTS

424.04 Subgrade Preparation. The subgrade shall be tamped or rolled until thoroughly compacted and at the proper line and grade as shown on the plans. At locations where sidewalk is constructed at entrances, the sidewalk shall be thickened to the thickness of the adjacent entrance or driveway pavement.

424.05 Forms. Side forms shall be of lumber of not less than 2 in. (50 mm) thickness or of steel of equal rigidity. They shall be held securely in place by stakes or braces, with the top edges true to line and grade. Forms for the sidewalk accessibility ramps shall be set so that the slab will have a uniform fall between the sidewalk proper and the curb grade.

At the Contractor's option, slipforming using equipment approved by the Engineer will be allowed.

424.06 Placing and Finishing. The subgrade shall be moistened just before the concrete is placed. The concrete shall be placed in successive batches for the entire width of the slab, struck-off, consolidated with a hand vibrator, and finished to a true and even surface with floats and trowels. A vibratory screed may be used to strike off, consolidate, and finish the concrete. The final finish shall be done with a wooden float, leaving an even surface. Steel trowels shall not be permitted. After the water sheen has disappeared, the surface shall be given a final finish by brushing with a whitewash brush. The brush shall be drawn across the sidewalk at right angles to the edges of the walk, with adjacent strokes slightly overlapping, producing a uniform, slightly roughened surface with parallel brush marks.

The surface shall be divided by grooves constructed at right angles to the centerline of the sidewalk. These grooves shall extend to 1/4 the depth of the sidewalk, shall be not less than 1/8 in. (3 mm) nor more than 1/4 in. (6 mm) in width, and shall be edged with an edging tool having a 1/4 in. (6 mm) radius. No slab shall be longer than 6 ft (1.8 m) nor less than 4 ft (1.2 m) on any one side, unless otherwise ordered by the Engineer. The edges of the slabs shall be edged as described above.

424.07 Expansion Joints. Expansion joints of the thickness specified below shall consist of preformed joint filler. The top of the joint shall be placed 1/4 in. (6 mm) below the surface of the sidewalk.

- (a) 1/2 in. (13 mm) Thick Expansion Joints. Expansion joints 1/2 in. (13 mm) thick shall be placed between the sidewalk and all structures such as light standards, traffic light standards, traffic poles and subway columns, which extend through the sidewalk.
- (b) 3/4 in. (20 mm) Thick Expansion Joints. Transverse expansion joints 3/4 in. (20 mm) thick shall be placed at intervals of not more than 100 ft (30 m) in the sidewalk. Where the sidewalk is constructed adjacent to pavement or curb having expansion joints, the expansion joints in the sidewalk shall be placed in line with the existing expansion joints as nearly as practicable. Expansion joints shall also be placed where the sidewalk abuts existing

sidewalks, between driveway pavement and sidewalk, and between sidewalk accessibility ramps and curbs where the ramp abuts a curb.

424.08 Curb Ramps. Curb ramps shall be constructed according to the ADAAG, the Illinois Accessibility code, and as shown on the plans.

Curb ramps shall be constructed to the same thickness as the adjacent sidewalk with a minimum thickness of 4 in. (100 mm).

424.09 Detectable Warnings. Detectable warnings shall consist of a surface of truncated domes meeting the requirements of the ADAAG and the details shown on the plans.

Detectable warnings shall be installed at curb ramps, medians and pedestrian refuge islands, at-grade railroad crossings, transit platform edges, and other locations where pedestrians are required to cross a hazardous vehicular way. Detectable warnings shall also be installed at alleys and commercial entrances when permanent traffic control devices are present. The installation shall be an integral part of the walking surface and only the actual domes shall project above the walking surface.

The product or method used for installing detectable warnings shall come with the following documents which shall be given to the Engineer prior to use.

- (a) Manufacturer's certification stating the product is fully compliant with the ADAAG.
- (b) Manufacturer's five year warranty.
- (c) Manufacturer's specifications stating the required materials, equipment, and installation procedures.

Products that are colored shall be colored their entire thickness.

The materials, equipment, and installation procedures used shall be according to the manufacturer's specifications.

424.10 Backfill. After the concrete has been cured, the spaces along the edges of the sidewalk and ramps shall be backfilled with approved material. The material shall be compacted until firm and the surface neatly graded.

424.11 Disposal of Surplus Material. Surplus or waste material shall be disposed of according to Article 202.03.

424.12 Method of Measurement. This work will be measured for payment in place and the area computed in square feet (square meters). Curb ramps will be measured for payment as sidewalk. No deduction will be made for detectable warnings located within the ramp.

Detectable warnings will be measured for payment in place and the area computed in square feet (square meters).

Earth excavation will be measured for payment according to Article 202.07.

424.13 Basis of Payment. This work will be paid for at the contract unit price per square foot (square meter) for PORTLAND CEMENT CONCRETE SIDEWALK, of the thickness specified.

Detectable warnings will be paid for at the contract unit price per square foot (square meter) for DETECTABLE WARNINGS.

Earth excavation required will be paid for according to Article 202.08.

PAVEMENT REHABILITATION

SECTION 440. REMOVAL OF EXISTING PAVEMENT AND APPURTENANCES

440.01 Description. This work shall consist of the complete removal of existing pavement, paved shoulders, driveway pavement, median, curb, gutter, combination curb and gutter, paved ditch, and sidewalk; the partial depth removal of concrete medians; and the removal of hot-mix asphalt (HMA) surfaces in preparation for subsequent resurfacing.

Pavement removal shall be defined as portland cement concrete or HMA pavement and shall include portland cement concrete or HMA bases, overlays, and stabilized subbase.

Paved shoulder removal shall be defined as portland cement concrete or HMA shoulders.

Gutter removal and combination curb and gutter removal shall include the complete removal of all inlets, outlets, and entrances contained within the limits of removal. The removal of outlets shall include the entire discharge trough and end curtain wall for trough type outlets and the concrete box and outlet pipe for drop box type outlets.

Paved ditch removal shall include the complete removal of all anchor walls and cut-off walls that are contained within the limits of removal.

440.02 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Self-Propelled Milling Machine	1101.16

CONSTRUCTION REQUIREMENTS

440.03 General. All existing pavement, including surface courses, base courses, and stabilized subbases, and other appurtenances as listed above, which interfere with construction work shall be completely removed as shown on the plans or as directed by the Engineer.

When portions of existing pavement and appurtenances are to remain in place, provisions shall be made for satisfactory transitions between replacements and the portions remaining in place. A full depth, perpendicular, straight joint shall be sawn at the ends and all edges of portions to be removed. Any damage done to the existing pavement or appurtenance to remain in place shall be repaired or removed and replaced as directed by the Engineer.

The thickness of the existing pavement to be removed, including overlays and other appurtenances, will be shown on the plans.

Gutter removal shall include the complete removal of all inlets, outlets and entrances that are contained within the limits of the designated removal. The removal of outlets shall include the entire discharge trough and end curtain wall for trough type outlets and the concrete box and outlet pipe for drop box type outlets.

Paved ditch removal shall include the complete removal of all anchor walls and cut-off walls that are contained within the limits of the designated removal.

Any excavation made by the Contractor for the removal shall be replaced. The excavated space shall be filled with material satisfactory to the Engineer and placed according to Section 205 at no additional cost to the Department.

440.04 HMA Surface Removal for Subsequent Resurfacing. The existing HMA surface shall be removed to the depth specified on the plans with a self-propelled milling machine. The temperature at which the work is performed, the nature and condition of the equipment, and the manner of performing the work shall be such that the milled surface is not torn, gouged, shoved or otherwise damaged by the milling operation. Sufficient cutting passes shall be made so that all irregularities or high spots are eliminated to the satisfaction of the Engineer. When tested with a 16 ft (5 m) straightedge, the milled surface shall have no surface variations in excess of 3/16 in. (5 mm).

Removing the existing HMA surface to the required depth adjacent to structures in the pavement surface such as drain castings and utility covers shall be accomplished in a manner satisfactory to the Engineer using either machine or hand methods. Castings for existing utility or drainage structures within the pavement which are exposed to traffic after the pavement has been milled shall be protected according to Article 603.07.

Milled pavement shall be resurfaced within ten calendar days.

440.05 Median Removal Partial Depth. The portland cement concrete median shall be removed to the depth specified with a self-propelled milling machine.

440.06 Disposal of Material. Materials resulting from the removal of existing pavement and appurtenances as herein specified shall be disposed of according to Article 202.03.

440.07 Method of Measurement. This work will be measured for payment as follows.

Art. 440.07 Removal of Existing Pavement and Appurtenances

- (a) Contract Quantities. The requirement for use of contract quantities shall be according to Article 202.07(a).
- (b) Measured Quantities. Pavement removal and driveway pavement removal will be measured for payment in place and the area computed in square yards (square meters).

HMA surface removal for subsequent resurfacing will be measured for payment in place and the area computed in square yards (square meters) for each specified increment thickness of material removed.

Curb removal, gutter removal, combination curb and gutter removal and paved ditch removal will be measured for payment in feet (meters). The measurement for curb removal and combination curb and gutter removal will be made along the face of the curb. The measurement for gutter removal and paved ditch removal will be made along the flow line.

Sidewalk removal, median removal and median removal partial depth will be measured for payment in place and the area computed in square feet (square meters).

Removal of any of the items listed above outside the designated limits as shown on the plans or as directed by the Engineer will not be measured for payment.

- (c) Adjustment of Quantities. The quantity of pavement removal will be adjusted if the thickness of the existing pavement varies more than 15 percent from that shown on the plans. The quantity will be either increased or decreased according to the following table.

% change of thickness	% change of quantity
0 to less than 15	0
15 to less than 20	10
20 to less than 30	15
30 and greater	20

When an adjustment is made for variations in pavement thickness a resulting adjustment will also be made in the earthwork quantities when applicable.

No adjustment will be made for variations in the amount of reinforcement.

440.08 Basis of Payment. This work will be paid for at the contract unit price per square yard (square meter) for PAVEMENT REMOVAL, DRIVEWAY PAVEMENT REMOVAL and PAVED SHOULDER REMOVAL; at the contract unit price per square yard (square meter) for HOT-MIX ASPHALT SURFACE REMOVAL, of the thickness specified; at the contract unit price per foot (meter) for CURB REMOVAL, GUTTER REMOVAL, COMBINATION CURB AND GUTTER REMOVAL, and PAVED DITCH REMOVAL; and at the contract unit price per square foot (square meter) for SIDEWALK REMOVAL, MEDIAN REMOVAL and MEDIAN REMOVAL PARTIAL DEPTH.

SECTION 441. RESERVED**SECTION 442. PAVEMENT PATCHING**

442.01 Description. This work shall consist of the removal of the existing pavement, the necessary excavation and the replacement with the class and type of patch specified at designated locations.

This work will be classified as follows.

Class A Patches:	Pavement Removal and Continuously Reinforced Portland Cement Concrete Replacement
Class B Patches:	Pavement Removal and Portland Cement Concrete Replacement Using Dowels or Tie Bars
Class C Patches:	Pavement Removal and Portland Cement Concrete Replacement
Class D Patches:	Pavement Removal and Hot-Mix Asphalt (HMA) Replacement
Pavement Patching:	Contractor's Option of Class C or Class D

For each of the above classifications, the work on a lane width or less shall be further quantified by size as follows.

Type I	Less than 5 sq yd (5 sq m)
Type II	5 sq yd (5 sq m) or more, but less than 15 sq yd (15 sq m)
Type III	15 sq yd (15 sq m) or more, but less than 25 sq yd (20 sq m)
Type IV	25 sq yd (20 sq m) or more

442.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete (Note 1)	1020
(b) Concrete Reinforcement Bars, Fabric, and Strand	1006.10
(c) Dowel Bars and Dowel Bar Assembly	1006.11
(d) Preformed Expansion Joint Fillers	1051.09
(e) Preformed Fiber Joint Filler	1051.04
(f) Hot-Mix Asphalt (HMA) (Note 2)	1030
(g) Nonshrink Grout	1024.02
(h) Hot-Poured Joint Sealer	1050.02
(i) Backer Rod (Note 3)	
(j) Material for Forming Joint Grooves (Note 4)	
(k) Chemical Adhesive Resin System	1027.01
(l) Calcium Chloride	1013.01
(m) Grout	1024.01

Note 1. When patching ramp pavements and two-lane pavements with two-way traffic, Class PP-2, PP-3, or PP-4 concrete shall be used for Class A, Class B, and Class C patches. For all other pavements, Class PP-1, PP-2, PP-3, or PP-4 concrete shall be used for Class A, Class B, and Class C patches.

Note 2. The mixture composition of the HMA used shall be IL-19.0 or IL-25.0 binder, designed with the same Ndesign as that specified for the mainline pavement.

Note 3. The backer rod shall be a closed-cell, plastic foam rod compatible with the sealant and the elevated temperatures of joint sealant application.

Note 4. Material for joint forms shall be suitable for forming the sealant reservoir to the width and depth as shown on the plans and of sufficient strength to retain its shape during concrete placement.

442.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Self-Propelled Pneumatic-Tired Rollers	1101.01
(b) Vibratory Rollers (Note 1)	
(c) Forms (Note 2)	1103.05
(d) Concrete Saw (Note 3)	
(e) Wheel Saw (Note 4)	
(f) Equipment and Devices for Removing Old Concrete Slabs (Note 5)	
(g) Drilling Machine (Note 6)	
(h) Miscellaneous Equipment	1103.17
(i) Membrane Curing Equipment	1101.09
(j) Heating Equipment for Joint Sealant (Note 7)	
(k) Skid Steer Loader Equipped with a Hydraulic Hammer	1101.14

Note 1. The vibratory rollers and tampers shall meet the approval of the Engineer.

Note 2. Wood forms will be permitted. The depth of form shall be plank width, the commercial dimension which equals the pavement thickness shown on the plans or the next larger commercial dimension.

Note 3. The concrete saw shall be equipped with a diamond blade of sufficient size to saw pavements full-depth and be capable of accurately maintaining cutting depth and alignment.

Note 4. The wheel saw shall be equipped with carbide-tipped rotating cutters and be capable of accurately maintaining cutting depth and alignment.

Note 5. As approved by the Engineer.

Note 6. The machine used for drilling the holes in the face of the existing pavement shall be capable of drilling the size and depth of holes as shown on the plans. The machine shall be equipped with a positive stop to control

the depth of hole. During use, the stop shall be calibrated at least once a day. A drill support system using the pavement surface as a reference shall be used to assure hole alignment at mid-depth of portland cement concrete pavement. Hand held tools will not be allowed.

Note 7. The heating equipment shall be an indirect heating type with positive temperature control, mechanical agitation and recirculating pumps.

CONSTRUCTION REQUIREMENTS

442.04 Keeping Road Open to Traffic. The road shall be kept open to traffic according to Article 701.17(e).

442.05 Pavement Removal. The pavement shall not be scored with a concrete saw or jackhammers more than three days prior to when it will be broken, except when the pavement is closed to traffic. The pavement shall not be scored with a wheel saw more than one day prior to when it will be broken, except when the pavement is closed to traffic.

If a wheel saw is used to score the pavement or areas of the pavement have been removed for purposes of cutting marginal bars and the pavement will be open to traffic, the cuts shall be filled with either full-depth cold bituminous mix meeting the approval of the Engineer or compacted granular material with a 2 in. (50 mm) minimum cap of cold bituminous mix meeting the approval of the Engineer. The cuts shall be constantly maintained so that they will not be a hazard to traffic.

Any drainage mat or pipe underdrains damaged during patching operations shall be repaired or replaced.

Materials resulting from the removal of the existing pavement and unsuitable and unstable materials shall be disposed of according to Article 202.03.

The scoring and removal of pavement for the various classes of patches shall be as follows.

- (a) Class A Patches. Two transverse saw cuts shall be made perpendicular to the centerline at each end of the patch, except that the saw cuts may be skewed slightly if necessary to maintain a minimum distance of 18 in. (450 mm) from the end of the patch to the nearest transverse crack in the pavement to remain in place. When approved by the Engineer, this minimum distance may be reduced to 6 in. (150 mm) in areas of close crack spacing where the pavement otherwise appears to be sound. The interior saw cut shall be made at the location that will provide the proper length of exposed existing steel as shown on the plans and shall be either full-depth or to a depth which will completely sever the longitudinal reinforcement. The longitudinal edges of the patch shall be formed by full-depth saw cuts. Patches one-half lane width or full lane width will be permitted. Saw cut extensions into pavement which is to remain in place will not be permitted. All outlining and interior saw cuts shall be made with an approved concrete saw. After the interior saw cuts have been made, an approved wheel saw may be used to make pressure relief cuts or intermediate cuts to reduce the

pavement length to a size that accommodates removal and hauling operations. The wheel saw cutting operations shall be controlled to limit subbase penetration to a maximum of 1/2 in. (13 mm).

The shoulder between the full-depth saw cut and the pavement edge shall be removed using a hand held hammer and hand tools prior to pavement removal. If available, the Contractor may use an approved wheel saw to make the shoulder cut and removal.

When the patch is adjacent to a portland cement concrete shoulder, a saw cut shall be made at the shoulder-pavement joint sufficiently deep to sever the tie bars. A second full-depth saw cut shall be made in the pavement a minimum of 4 in. (100 mm) from the edge of the shoulder. The pavement between the full-depth saw cut and the shoulder edge shall be removed using a hand held hammer and hand tools prior to removal of the remaining pavement.

The pavement between the interior saw cuts shall be removed by lifting. Sufficient care shall be taken to minimize subbase disturbance and prevent spalling of the pavement that is to remain in place. Any subbase or stabilized subbase material disturbed during pavement removal operations or determined unsuitable by the Engineer shall be removed and replaced with patch material.

If the Engineer determines that the concrete has deteriorated to the extent that it is not practical to lift, the pavement may be broken into small pieces and removed. The breaking equipment shall not transfer an impact energy greater than 3000 ft lb (4000 J) per blow to the pavement surface.

The concrete in the splicing area, between the interior and outer saw cuts, shall be removed using hand held hammers and hand tools. The Contractor has the option to use a skid steer loader equipped with a hydraulic hammer to remove the concrete in the splicing area. Should the loader and hydraulic hammer damage the pavement and/or reinforcement which are to remain in place, the loader with a hydraulic hammer will no longer be allowed.

To prevent underbreaking concrete to remain in place, the face of the concrete below the partial-depth saw cut shall be inclined slightly into the patch. The reinforcing steel in the splicing area shall not be bent to aid in removal of the concrete. If more than ten percent of the reinforcing steel in the splice area is damaged due to the Contractor's operations, the patch shall be lengthened to provide the required steel exposure for splicing. If less than ten percent of the existing lap steel is damaged, it may be repaired by welding in lieu of lengthening the patch. No welding will be permitted on the splices between the existing steel and the new steel.

Should the Contractor's operations cause a spall having a width or depth greater than 1 in. (25 mm) in the pavement to remain in place or cause excessive shattering or underbreaking of the existing slab to remain in place, a new saw cut shall be made extending the patch to remove the spall or underbreaking. After pavement removal, the pavement structure will be inspected by the Engineer to determine if it is sufficiently sound. If

determined unsound, the Contractor shall extend the patch as directed by the Engineer.

The existing reinforcement steel shall be observed during the removal process to determine if there is any excess rusting or evidence of steel distress. Deteriorated steel will not be permitted in the splice area. The Engineer may require lengthening of the patch.

- (b) Class B Patches. Two transverse saw cuts outlining the patch shall be straight and perpendicular to the centerline, with a tolerance of 2 in. (50 mm) in 12 ft (3.6 m). The wedge of pavement formed by the interior (third) saw cut shall be removed with a hand held hammer and hand tools prior to pavement liftout. Saw cut extensions into pavement which is to remain in place will not be permitted. All saw cuts shall be made with an approved concrete saw (except as outlined below). Concrete not sawed full-depth shall be removed with hand tools. Only full lane width patches will be permitted.

When the patch is adjacent to a HMA shoulder, a full-depth saw cut shall be made in the shoulder a minimum of 4 in. (100 mm) from the edge of the pavement or at such width as to facilitate forming. The shoulder between the full-depth saw cut and the pavement edge shall be removed with a hand held hammer and hand tools prior to pavement liftout.

When the patch is adjacent to a portland cement concrete shoulder, a saw cut shall be made at the shoulder-pavement joint sufficiently deep to sever the tie bars. A second full-depth saw cut shall be made in the pavement a minimum of 4 in. (100 mm) from the edge of the shoulder. The pavement between the full-depth saw cut and the shoulder edge shall be removed using a hand held hammer and hand tools prior to removal of the remaining pavement.

The Contractor may use an approved wheel saw to make the shoulder cut and removal, and to make pressure relief cuts or intermediate cuts to reduce the pavement length to a size that accommodates removal and hauling operations. The wheel saw cutting operations shall be controlled to limit subbase penetration to a maximum of 1/2 in. (13 mm). Wheel saw cuts shall be made after concrete sawing outlining patch boundaries, unless the wheel saw cuts are at least 18 in. (450 mm) inside the transverse patch boundaries. Should the Contractor be unable to conform to the requirements specified herein, the Engineer will withdraw approval of this alternative.

The pavement shall be removed by lifting. If the Engineer determines that the concrete has deteriorated to the extent that it is not practical to lift, the pavement may be broken into small pieces and removed. Breaking operations shall start adjacent to the removed wedge or the alternate wheel saw cut. The breaking equipment shall not transfer an impact energy greater than 3000 ft lb (4000 J) per blow to the pavement surface.

Care shall be taken to prevent subbase disturbance and spalling of the pavement which is to remain in place. Should the Contractor's operations

cause a spall having a width or depth greater than 1 in. (25 mm), a new saw cut shall be made extending the patch to remove the spall. After slab removal, the existing pavement structure will be inspected by the Engineer to determine if it is sufficiently sound. If determined unsound, the Contractor shall extend the patch as directed by the Engineer. Any subbase or stabilized subbase material that is disturbed during pavement removal operations or determined unsuitable by the Engineer shall be removed and replaced with patch material.

Resawing of patch boundaries to remove spalls that exceed a width or depth of 1 in. (25 mm) will not be required when the patching is being performed to prepare the existing pavement for resurfacing with HMA.

- (c) Class C and Class D Patches. Standard reinforced concrete pavement shall be scored with a concrete saw to a depth which severs the reinforcement. If the Contractor elects, he/she may saw full depth to alleviate spalling and replacement as specified in Article 442.05(a).

Non-reinforced concrete pavement shall be scored with jackhammers or other equipment approved by the Engineer. The scoring shall be at least 6 in. (150 mm) from the marked face of the patch. Marginal bars and tie bars shall be cut in a manner satisfactory to the Engineer.

As an alternate, the Contractor may use an approved wheel saw to score the pavement full-depth on either standard reinforced or non-reinforced pavement. Should the wheel saw damage the pavement and/or reinforcement which are to remain in place, the Engineer will withdraw approval of this alternate.

The existing pavement shall be removed as shown on the plans. Ends of the patch need not be squared but may follow the existing cracks, provided angles smaller than those shown on the plans do not result.

If the patch is not scored with a concrete saw or wheel saw, the ends of the patch shall be hand trimmed with hand held hammers or other tools or equipment approved by the Engineer. The general plane of the cut face shall not deviate more than 1 1/2 in. (40 mm) from vertical. Abrupt breaks or deviations from the plane of the cut face sufficient to induce spalling in either the top or the bottom surface of the pavement will not be permitted.

Should the Contractor's operations cause a spall having a width or depth greater than 1 in. (25 mm), the patch shall be extended to remove the spall. This extension will not be required when the patching is being performed to prepare the existing pavement for resurfacing with HMA.

Equipment and methods used for removing old pavement shall be such as to prevent cracking, shattering or spalling of the pavement remaining in place. Breaking equipment shall not transfer an impact energy greater than 3000 ft lb (4000 J) per blow to the pavement surface.

After breaking and removal of the existing pavement, any areas of the subbase which are below the required elevation of the finished subbase,

shall be built up to grade with satisfactory compacted granular material, concrete or compacted HMA.

Tie bars extending across the longitudinal joint, or such portion as may be exposed in the area of the patch, shall be cut approximately at the face of the pavement which is to remain in place, or they shall be removed. Marginal bars shall be cut close to the face of the pavement which is to remain in place.

442.06 Pavement Replacement. Class A, Class B, and Class C patches shall conform to the standard details and cross section included in the plans, and the work shall conform to the applicable portions of Section 420, with the following exceptions.

- (a) Reinforcement, Dowel Bars, and Joints. Reinforcement, dowel bars, and joints shall be according to the following.
 - (1) Class A Patching. The reinforcement shall be as shown on the plans. Patches more than 20 ft (6 m) in length, including half-lane patches, shall be tied to the adjacent pavement, portland cement concrete shoulders, and curb and gutter with No. 6 (No. 19) transverse tie bars, 24 in. (600 mm) long, embedded 8 in. (200 mm) at 24 in. (600 mm) centers according to Article 420.05(b).

The Contractor shall tie the steel together, using at least two secure ties for each lap splice.

Should an existing lap splice be encountered in the patch splice area, the Contractor shall construct the new splice by tying both of the exposed reinforcement bars to the new reinforcement bar.

Reinforcement steel shall be placed and supported on chairs according to Article 421.04(a) such that uniform unsupported lengths not exceeding 4 ft (1.2 m) are provided. In such cases where an uneven subbase hinders maintenance of a placement tolerance of ± 1 in. (25 mm) vertically, portland cement concrete, grout (mix one part cement and two parts sand with water), or HMA shall be used to adjust the chair height to allow the reinforcement to be placed within the specified tolerances.

When the existing reinforcement is fabric, the longitudinal reinforcement bars shall be the same size and spacing as the existing longitudinal reinforcement.

- (2) Class B Patching. Dowel bar holes shall be drilled as shown on the plans. The holes shall be parallel to the grade and centerline of the pavement with a tolerance of 1/8 in. (3 mm) in 12 in. (300 mm). The drilling operation shall not crack or spall the pavement.

Immediately prior to grouting the dowel bars, the holes shall be thoroughly cleaned of drilling debris. Dust and debris shall be blown from the hole with a power brush/blower or with compressed air. If

compressed air is used, the pneumatic tool lubricator shall be bypassed and a filter installed on the discharge valve to keep water and oil out of the lines. The dowel bars shall be clean and free from rust.

An approved chemical adhesive shall be used as the anchoring material for dowel bars.

The chemical adhesive shall be of a consistency such that the dowel may be easily inserted into the hole with flow completely surrounding the dowel, and without appreciable runoff of chemical adhesive after the bar is fully inserted. The chemical adhesive shall be injected to the back of the hole to eliminate air pockets prior to inserting the bar. The quantity of material used shall be such that the chemical adhesive is dispersed along the entire length of the bar and voids are completely filled. After the material has been positioned at the back of the hole, the dowel shall be fully inserted, using a back-and-forth twisting motion, leaving the proper length exposed as shown on the plans. If it is necessary to use a hammer to aid in seating a dowel, the exposed end of the dowel shall be protected with a wood block.

Immediately prior to placing the concrete, the exposed ends of dowel bars shall be cleaned and lightly oiled.

Patches more than 20 ft (6 m) in length shall be tied to the adjacent lane of pavement, portland cement concrete shoulders, and curb and gutter with No. 6 (No. 19) transverse tie bars, 24 in. (600 mm) long, embedded 8 in. (200 mm) at 24 in. (600 mm) centers according to Article 420.05(b).

Contraction joints shall be constructed within patches as follows.

- a. Pavements with 15 ft (4.5 m) Joint Spacing. For pavements designed with a typical 15 ft (4.5 m) joint spacing, patches more than 20 ft (6 m) in length shall have transverse contraction joints constructed according to Article 420.05(c) at 15 ft (4.5 m) maximum intervals. The contraction joints shall be in line with joints or cracks in the adjacent lane whenever possible. The minimum distance between new and/or existing joints shall be 6 ft (2 m).
- b. Other Pavements. For all other types of jointed pavement designs, patches 45 ft (14 m) or longer shall have transverse contraction joints installed at regular intervals according to the joint spacing of the existing pavement.

Type III or Type IV patches shall be reinforced with pavement fabric according to the details shown on the plans. The reinforcement shall be placed at 3 1/2 in. \pm 1 in. (90 mm \pm 25 mm) below the finished patch surface elevation according to Article 420.08.

- (3) Class C Patching. When the patched pavement is not to be resurfaced, transverse contraction joints shall be formed on 15 ft (4.5 m) to 20 ft (6 m) centers by sawing in all patches that are more than 20 ft (6 m) in

length. They shall be placed in line with joints or cracks in the existing slab whenever possible.

- (b) Replacing Full-Width Pavement. Unless through traffic is detoured, full-width pavement shall be replaced in two or more operations. When full-width pavement is replaced in two or more operations, a form shall be installed along the lane line by one of the following methods.
 - (1) Method 1. Whenever practicable, an approved form, not less than 1/4 in. (6 mm) in thickness, shall be set along the longitudinal joint when placing the patch in the first half-width. The depth of this form shall be equal to the thickness of the new pavement being placed, or as close thereto as standard lumber measurements will allow. No pavement in the lane open to traffic shall be removed to permit setting the form, and the form shall remain in place until the existing pavement in the opposite half-width is removed.
 - (2) Method 2. When the existing pavement in the opposite half-width is so broken or disintegrated that it is not feasible to use Method 1, a wood form shall be set along the longitudinal joint when placing the patch in the first half-width, except that a metal form may be used for Type III patches when mechanical finishing is employed. Only sufficient concrete shall be removed from the lane open to traffic to permit setting the form. As soon as permissible after the concrete is poured, the form shall be removed, and the trench occupied by the form shall be filled immediately with compacted granular material, which shall be constantly maintained in such a manner that it will not be a hazard to traffic.

When replacing adjacent lanes in one operation, the longitudinal joint down the lane line shall be a sawed longitudinal joint as specified in Article 420.05(a), except that tie bars shall only be included for patches that are more than 20 ft (6 m).

- (c) Forms. Forms and bond breaker shall be according to the following.
 - (1) Side forms will be required.
 - (2) For Class B patches, a bond breaker of 1/4 in. (6 mm) fiber joint filler, or other material approved by the Engineer, shall be placed flush with the surface at the pavement centerline for the full length and depth of the patch. If the centerline sealant reservoir is to be formed, that part of the bondbreaker may be replaced by the joint reservoir form.
- (d) Concrete Placement. Concrete shall be placed according to Article 420.07, except a mechanical concrete spreader will not be required. Placement shall be governed by the limitations set forth in Article 1020.14.

In the case of Class A patches, if the subbase and subgrade material have been disturbed and/or removed in excess of plan pavement thickness plus subbase thickness or more from the surface of the pavement, the concrete shall be placed in lifts and separated by a bond breaker. The elevation of

the bottom lift shall be level with the top of the subbase. A thin coating of rapid setting asphalt emulsion or thick coating of Type III curing compound shall be applied to the surface of the bottom lift. Care shall be taken to avoid coating the vertical faces of the existing pavement or any reinforcement. The remainder of the concrete shall be placed after the asphalt emulsion or curing compound has sufficiently cured; but not before at least one day after placement of the bottom lift.

- (e) Consolidating and Finishing. The concrete shall be consolidated by internal vibration. Special attention shall be given to consolidating the concrete around the corners, edges, dowel bars, tie bars, and reinforcement.

For Class A and Class B patches, the surface of the patch shall be struck off with two passes of a vibratory or rolling screed as approved by the Engineer. For Class C patches, finishing may be performed by either machine or hand methods. For repairs 12 ft (3.6 m) or less in length, the screed shall be placed parallel to the edge of pavement. For repairs over 12 ft (3.6 m) in length, the screed shall be placed perpendicular to the edge of pavement. In striking off, the template shall be moved forward with a combined longitudinal and transverse shearing motion, moving always in the direction in which the work is progressing and manipulated so that neither edge is raised during the striking off process. A slight excess of concrete shall be kept in front of the cutting edge at all times during the striking off operation.

After strike off, but while the concrete is still plastic, the surface of the concrete shall be tested for trueness by means of a 10 ft (3 m) straightedge according to Article 420.09(c).

Testing for hardened concrete shall be with a 10 ft (3 m) straightedge centered on the leading transverse patch boundary and continue until centered over the trailing patch boundary. The allowable tolerance used during testing shall be 3/16 in. (5 mm).

Surface variations which exceed the above tolerances shall be marked by the Engineer and removed by the Contractor with an approved grinding device consisting of multiple saws. The use of a bush hammer or other impact devices will not be permitted.

For Class A and Class B patches which will not be overlaid, the surface shall be stamped with the current year approximately 12 in. (300 mm) from the outer edge of the lane.

- (f) Brooming and Edging. When patching pavements which have not been overlaid, the final finish shall match the surrounding pavement. When patching pavements which have been overlaid, the surface of the concrete shall be textured with a broom finish applied transversely to the pavement centerline. The texturing operation shall be executed so that the surface is uniform in appearance and free from rough and porous spots, irregularities and depressions. If directed by the Engineer, concrete adjacent to a longitudinal joint shall be edged.

- (g) Curing and Protection. In addition to Article 1020.13, when the air temperature is less than 55 °F (13 °C), the patch shall be covered with a minimum R12 insulation until opening strength is reached. Insulation is optional when the air temperature is 55 – 96 °F (13 – 35 °C). Insulation shall not be placed when the air temperature is greater than 96 °F (35 °C).

When patching two or more lane widths of continuously reinforced concrete pavement in one operation and extreme daily temperature cycles are anticipated, the Engineer may require that 200 ft (60 m) of pavement on each end of the patch be covered with wet straw and burlap or an approved insulation blanket, and that the patch be cured with wet burlap and covered in a similar manner. When covering is required, it shall be in place during the curing period. If wet straw and burlap is used, it shall be maintained in a wet condition throughout the curing period. When this type of covering is required by the Engineer, it will be paid for according to Article 109.04.

- (h) Shoulder Replacement. After the forms are removed but prior to opening to traffic, the disturbed shoulder area shall be replaced with like material, compacted and restored to the existing line and grade.
- (i) Joint Sealing. Joints shall be sealed according to the following.

- (1) In Class A patches, all centerline joints and longitudinal joints adjacent to portland cement concrete shoulders shall be sealed according to Article 420.12.
- (2) In Class B patches, all transverse joints, centerline joints, longitudinal joints adjacent to portland cement concrete shoulders, and saw-cut extensions in the shoulders shall be sealed according to Article 420.12 and manufacturer's recommendations. The sealant reservoir at patch boundaries shall be formed in the fresh concrete or sawed to the dimensions shown on the plans. If the reservoir is to be sawed, sawing shall not be performed until after the required curing period. The faces of the reservoir shall be thoroughly cleaned by sandblasting and then blown clean with compressed air. When the compressed air is used, the pneumatic tool lubricator shall be bypassed and a filter installed on the discharge valve to keep oil and water out of the line. The backer rod shall be uniformly placed at the depth shown on the plans or as directed by the Engineer.

The sealing shall be done in one pour to fill the transverse joint and the centerline joint. Reheated or overheated material shall not be used.

At the Contractor's option, the centerline joint may be sawed/formed and sealed in a manner similar to the transverse joint.

- (3) In Class C patches, transverse contraction joints shall be sealed according to Article 420.12.
- (4) Sealing of joints as specified in (1), (2), and (3) will not be required when patching is being performed to prepare the existing pavement for resurfacing with HMA.

442.07 Expansion Joints. Where expansion joints exist in the portion of the pavement that is to remain in place, the adjacent new pavement shall be constructed when possible with a similar type joint. Where existing joints are obsolete or unobtainable, the expansion joint material may be any preformed expansion joint filler meeting the requirements of Section 1051.

In Class B patches, expansion joints shall be constructed as shown on the plans. The expansion joint materials shall be according to Article 1051.09, and the joints shall be sealed as specified in Article 420.12.

442.08 Class D Patching. Class D patching shall conform to the standard details and cross sections shown on the plans.

- (a) **Filling Holes.** The HMA shall be placed only when the temperature in the shade is at least 40 °F (5 °C), the forecast is for rising temperature, and the subgrade is not frozen. The HMA shall be placed in two or more lifts with the minimum compacted lift thickness according to Article 406.06(d). Each lift shall be compacted with a mechanical tamper, a vibrating tamper, or a self-propelled roller. Trucks may be used to supplement the tampers or roller.

To facilitate possible extra compaction and consolidation by traffic, the surface of the completed patch may be finished up to 1/2 in. (13 mm) above the existing pavement.

- (b) **Density.** The density of the compacted HMA shall be according to Articles 1030.05(d)(3), (d)(4), and (d)(7).
- (c) **Additional Compaction.** Traffic shall be permitted on the patches for at least three days prior to resurfacing.
- (d) **Maintenance of Patch.** The surface of the completed patch shall be maintained in a smooth condition. Patches open to traffic that are constructed high or become rough shall be corrected within 24 hours by trimming off high areas and/or filling depressions. Filled areas shall be rerolled to obtain the required density.

If the patched pavement is to be resurfaced on the same contract, minor depressions in the patch surface may be filled and compacted as a part of the resurfacing operation.

442.09 Opening Patches to Traffic. Patches shall be opened to traffic according to Article 701.17(e). If patches are not opened when required, the Contractor shall adjust his/her construction operations, or in the case of concrete patching, the mix design. The Engineer may establish a shut-off time when all patch holes shall be filled.

Should delays of any type or for any reason prevent the opening of patches on multilane roadways, temporary patches shall be constructed. Material able to support the average daily traffic and meeting the approval of the Engineer shall be used for

the temporary patches. When they are no longer required, the temporary patches shall be disposed of according to Article 202.03.

442.10 Method of Measurement. Pavement removal and replacement of the various classes and types will be measured for payment in place, and the area computed in square yards (square meters).

To the extent possible, the contract documents contain information on the thickness of the existing pavement including subsequent resurfacing(s). In the event the average combined thickness of the existing pavement and overlays in an area to be patched differs from the thickness shown on the plans, the Engineer will adjust the patching quantity, for the specific patch type, and saw cut quantity of the individual patches meeting this requirement as indicated by the following chart. The quantities will be increased when the thickness is greater, and decreased when the thickness is less, as follows.

% change of thickness	% change of quantity
0 to less than 15	0
15 to less than 20	10
20 to less than 30	15
30 and greater	20

No other compensation will be allowed for variations in patching thickness from that shown on the plans.

If additional pavement, subbase, or subgrade material is removed due to negligence on the part of the Contractor, the additional quantity of pavement removal and replacement or subgrade material will not be measured for payment. Shoulder removal and replacement resulting from edge forming will not be measured for payment.

When expansion joints are to be included in Class B patches, as shown on the plans or as directed by the Engineer, the expansion joint will be measured for payment in place in feet (meters).

Reinforcement bars will be computed in square yards (square meters) of surface area of the pavement patch in which the pavement reinforcement is installed, and no allowance will be made for laps, splices, or portions of bars not used.

Pavement fabric will be computed in square yards (square meters) of surface area of the pavement patch in which the pavement reinforcement fabric is installed.

All mandatory saw cuts for removal operations for Class A or Class B patches will be measured for payment in place in feet (meters). Optional saw cuts with a concrete saw or wheel saw to aid the Contractor's removal operation will not be measured for payment. Optional wheel saw cuts allowed in lieu of mandatory saw cuts will be measured for payment as though the mandatory saw cuts were performed.

442.11 Basis of Payment. Where the Contractor has the option of using either Class C or Class D patches, this work will be paid for at the contract unit price per square yard (square meter) for PAVEMENT PATCHING, of the type and thickness specified.

Where the Department requires a specific class of patch be used, this work will be paid for at the contract unit price per square yard (square meter) for CLASS A PATCHES, CLASS B PATCHES, CLASS C PATCHES, OR CLASS D PATCHES, of the type and thickness specified.

When expansion joints are included in Class B patches, the expansion joint will be paid for at the contract unit price per foot (meter) for CLASS B PATCH – EXPANSION JOINT. The deformed bars will be paid for at the contract unit price per each for DEFORMED BARS – EXPANSION JOINT.

Where unsuitable material is encountered in the subgrade or subbase and its removal and replacement is required by the Engineer, such removal and replacement will be paid for according to Article 109.04.

Where damaged areas occur in the stabilized subbase as a result of the subbase adhering to the removed slab, the area shall be replaced with patch material and will be paid for according to Article 109.04. Any removal or disposal costs for the additional material that adhered to the removed slab shall be included in the contract unit price for the item(s) of patching involved.

When additional pavement removal due to unsound concrete or deteriorated steel is directed by the Engineer, the additional quantities will be paid for according to Article 109.04.

Dowel bars will be paid for at the contract unit price per each for DOWEL BARS, of the diameter specified.

Pavement tie bars for Class A and Class B patches will be paid for at the contract unit price per each for TIE BARS, of the diameter specified.

Reinforcement bars will be paid for at the contract unit price per square yard (square meter) for PATCHING REINFORCEMENT.

Mandatory saw cuts for Class A and Class B patches will be paid for at the contract unit price per foot (meter) for SAW CUTS.

When pavement reinforcement fabric is included in the contract it will be paid for at the contract unit price per square yard (square meter) for PAVEMENT FABRIC. When pavement reinforcement fabric is required for patching, and a pay item is not included in the contract, the cost of the fabric will be paid for according to Article 109.04.

SECTION 443. REFLECTIVE CRACK CONTROL TREATMENT

443.01 Description. This work shall consist of constructing reflective crack control treatments. Area reflective crack control treatment shall be either System A or C at the option of the Contractor. Strip reflective crack control treatment shall be either System A, B, C, or D at the option of the Contractor.

443.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Reflective Crack Control System	1062
(b) Preparation of Mixture for Cracks, Joints, and Flangeways	1030.07
(c) Hot-Poured Joint Sealer	1050.02
(d) Bituminous Materials (Note 1) (Note 2) (Note 3) (Note 4)	1032

Note 1. The asphalt binder used for System A shall be PG 58-22 or PG 64-22 meeting the requirements of Article 1032.05(a).

Note 2. The primer to be used with System B shall be supplied by the manufacturer of the membrane and shall be compatible with the membrane.

Note 3. The tack coat to be used with System C shall be SS-1, SS-1h, SS-1hP, CSS-1, CSS-1h, or CSS-1hP meeting the requirements of Article 1032.06.

Note 4. The two applications of tack coat to be used with System D shall be according to the following.

The tack coat for applying the membrane to the pavement surface shall be PG 64-22, PG 58-28, or PG 52-28 meeting the requirements of Article 1032.05(a).

The tack coat applied to the top of the membrane prior to the HMA overlay shall be SS-1, SS-1h, SS-1hP, CSS-1, CSS-1h, or CSS-1hP meeting the requirements of Article 1032.06. Cutback asphalts shall not be used.

443.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Rollers	1101.01
(b) Mechanical Sweeper	1101.03
(c) Asphalt-Rubber Processor/Distributor	1101.17
(d) Mechanical Laydown Equipment	1101.18
(e) Aggregate Spreaders	1102.04
(f) Pressure Distributor	1102.05

CONSTRUCTION REQUIREMENTS

443.04 Surface Preparation. The surface on which reflective crack control system is to be constructed shall be clean and dry. Base failures shall be repaired. Cracks, spalls, potholes, or other depressions shall be sealed with an approved crack sealer or filled with mixture for cracks, joints, and flangeways according to Article 406.05.

When, in the opinion of the Engineer, the existing pavement surface cannot be rendered sufficiently smooth by crack sealing and patching, a leveling binder shall be placed prior to construction of the reflective crack control system. The leveling binder shall be constructed according to Section 406.

443.05 Placing Hot-Mix Asphalt (HMA). When HMA leveling binder, binder course, or surface course is placed on top of any reflective crack control system, the mixture shall be placed at a maximum temperature of 300 °F (150 °C).

443.06 Reflective Crack Control System A. The area to be covered with fabric shall be sprayed uniformly with asphalt binder at a rate of 0.25 to 0.30 gal/sq yd (1 to 1.3 L/sq m) as directed by the Engineer. Binder application shall be accomplished with a pressure distributor for all surfaces, except where the distributor does not have room to operate, hand spraying will be allowed. The width of the spray application shall be no more than 6 in. (150 mm) wider than the fabric and no less than the fabric width plus 2 in. (50 mm). The binder shall not be applied at a temperature greater than 325 °F (160 °C) to avoid damage to the fabric.

After the binder has been sprayed, the fabric shall be unrolled or hand placed onto the binder without delay. Every effort must be made to lay the fabric as smoothly as possible to avoid wrinkles. Wrinkles large enough to cause laps of the fabric shall be cut and laid out flat. The fabric shall be broomed or squeegeed to remove air bubbles and make complete contact with the road surface.

The fabric shall overlap the adjacent fabric panel a minimum of 2 in. (50 mm). Additional asphalt binder shall be applied by hand to make the joints where overlap is greater than 2 in. (50 mm). The transverse joints shall be made in such a manner to avoid pickup by the paver. The direction of paving shall be in the direction of fabric placement.

When placed as a strip treatment, the strip shall be 24 in. (600 mm) wide.

443.07 Reflective Crack Control System B. The primer to be used with the waterproofing membrane shall be supplied by the manufacturer of the membrane and shall be compatible with the membrane.

The waterproofing membrane interlayer shall be placed as shown on the plans. Placement of the membrane shall be done only when the temperature is above 40 °F (5 °C) and the pavement surfaces are dry and free of dirt and debris.

The surface shall be primed according to the manufacturer's recommendations prior to placement of the membrane. The primer shall be placed at a minimum rate of 300 sq ft/gal (7 sq m/L), shall extend 1 in. (25 mm) wider than the membrane, and

shall be allowed to dry until tackfree before applying the membrane. Primer shall be placed on both portland cement concrete and HMA pavement surfaces.

Any spall greater than 3 in. (75 mm) in diameter which will cause a failure of the material to bond to the pavement or will leave a cavity under the material shall be corrected prior to the placement of the waterproofing membrane interlayer.

The membrane shall be installed in nominal 12 in. (300 mm) widths [11 3/8 in. (290 mm) minimum] and shall be centered over the joint or crack within a 1 in. (25 mm) tolerance. Laps will be permitted in the membrane with a minimum overlap of 2 1/2 in. (63 mm). The membrane shall be installed straight and wrinkle-free with no curled or uplifted edges. Any wrinkles over 3/8 in. (10 mm) width shall be slit and folded down.

All membrane shall be surface dry before placement of the hot-mix asphalt (HMA) overlay. Paving may begin immediately after membrane placement.

443.08 Reflective Crack Control System C. Immediately prior to application of a tack coat, the surface shall be thoroughly cleaned by sweeping.

When placed as a strip treatment, the strip shall be 24 in. (600 mm) wide. Also when placed as a strip treatment, a self-propelled distributor will not be required for applying the tack coat nor the asphalt-rubber, nor will a self-propelled spreader be required to place the cover aggregate. Equipment which meets the approval of the Engineer and applies a uniform application of tack coat, asphalt rubber, and cover aggregate may be used.

- (a) **Tack Coat.** A tack coat of diluted emulsified asphalt, of the type and grade specified in Article 1062.03, shall be applied to the cleaned surface and allowed to fully cure before spreading of the asphalt rubber material. The emulsified asphalt shall be diluted one part water to one part emulsified asphalt by volume with from 0.10 to 0.15 gal/sq yd (0.4 to 0.7 L/sq m) of the diluted material applied.
- (b) **Asphalt-Rubber Mixture.** For the asphalt-rubber mixture, the Contractor has the choice of using either a vulcanized rubber in asphalt with a diluent (Mixture 1) or a crumb rubber blend in asphalt which has been treated with an extender oil (Mixture 2).
 - (1) **Mixture 1.** The percentage of vulcanized rubber shall be 33 ± 4 percent by weight (mass) of the asphalt cement in Mixture 1.

The temperature of the asphalt shall be between 350 and 400 °F (175 and 200 °C) before addition of the vulcanized rubber. The material shall be carefully combined and mixed and reacted for a period of time as required by the Engineer which shall be based on laboratory testing by the asphalt-rubber supplier or contracting agency.

The temperature of the asphalt-rubber mixture shall be above 325 °F (160 °C) during the reaction period.

After the reaction between asphalt and rubber has occurred, the viscosity of the hot asphalt-rubber mixture may be adjusted for spraying and/or better "wetting" of the cover material by the addition of a diluent. The diluent shall not exceed 7 1/2 percent by volume of the hot asphalt-rubber mixture.

If a job delay results after the full reaction has occurred, the material may be allowed to cool and be slowly reheated to an acceptable spraying temperature just prior to application. However, because of the polymer reversion that can occur when crumb rubber is held for prolonged high temperatures, the material shall not be reheated to temperatures above 325 °F (160 °C). Additional diluent up to a maximum of three percent by volume of the hot asphalt-rubber mixture may be used after reheating of the material.

- (2) Mixture 2. The percentage of crumb rubber blend shall be 25 ± 4 percent by weight of the asphalt cement. Prior to adding the crumb rubber blend, the asphalt and extender oil shall be mixed in such quantities to produce an absolute viscosity of 600 poises (60 Pa·s) at 140 °F (60 °C) when tested according to the requirements of AASHTO T 202. The asphalt oil blend shall first be heated to 400 °F (200 °C) minimum and be thoroughly mixed before beginning incorporation of the crumb rubber blend. The crumb rubber blend shall be added as quickly as possible and the mix shall be given adequate circulation and agitation during the addition-mixing process to provide for proper dispersion. As soon as the mixing of the rubber is complete, Mixture 2 may be applied to the roadway. However, if the material is not to be used within one hour of mixing, the temperature shall be reduced to below 325 °F (160 °C) and reheated on the project site.
- (c) Application of Asphalt-Rubber Material. Placement of the asphalt-rubber shall be made only under the following conditions.
 - (1) The pavement surface temperature is not less than 60 °F (15 °C) and rain is not imminent;
 - (2) The pavement surface is clean and dry;
 - (3) The wind conditions are such that excessive blowing of the spray bar fans is not occurring, and
 - (4) All construction equipment such as asphalt-rubber distributor, aggregate spreader, haul trucks with cover aggregate, and rollers are in position and ready to commence placement operations.

The asphalt-rubber mixture shall be applied at a temperature of 290 to 325 °F (140 to 160 °C) at a rate of 0.6 ± 0.05 gal/sq yd (2.7 ± 0.2 L/sq m) [based on 7.5 lb/hot gal (0.9 kg/hot L)]. Transverse joints shall be constructed by placing building paper across and over the end of the previous asphalt-rubber application. Once the spraying has progressed beyond the paper, the paper shall be removed immediately

and disposed of as directed by the Engineer. All longitudinal joints shall be lapped a minimum of 4 in. (100 mm).

- (d) Application of Cover Material. Cover material shall be applied immediately to the asphalt-rubber after spreading at a rate of 30 to 40 lb/sq yd (16 to 22 kg/sq m). If steel slag is used for cover material, the spread quantity shall be increased in proportion to its higher specific gravity.

At the time of application to the asphalt-rubber, cover aggregate shall not contain any free moisture.

- (e) Rolling. At least three pneumatic-tired rollers shall be provided to accomplish the required embedment of the cover material. At some project locations or where production rates indicate, fewer rollers may be utilized as directed by the Engineer.

Sufficient rollers shall be used for the initial rolling to cover the width of the aggregate spread with one pass. The first pass shall be made immediately behind the aggregate spreader, and if the spreading is stopped for any reason, the spreader shall be moved ahead or off to the side so that all cover material may be immediately rolled. Four complete coverages with rollers shall be made with all rolling completed within two hours after the application of the cover material.

- (f) Opening the Completed Asphalt-Rubber Membrane Interlayer to Traffic. Except when it is necessary that hauling equipment must be on the newly applied membrane, traffic of all types shall be kept off the membrane until it has had time to set properly. The speed of all hauling equipment shall not exceed 15 mph (25 km/hr) when traveling over a membrane which is not adequately set. The minimum traffic free period shall be at least two hours.
- (g) Removing Loose Cover Aggregate. Following placement of the system, the loose cover aggregate shall be removed with a mechanical sweeper without dislodging any embedded aggregate.
- (h) Placement of HMA. The placement of the HMA overlay shall be delayed as directed by the Engineer for sufficient time to allow for adequate evaporation of the diluent or extender oil. A minimum of two hours shall elapse.

443.09 Reflective Crack Control System D. The stress relief membrane shall be applied when the surface temperature is a minimum of 50 °F (10 °C) and rising.

- (a) Tack Coat Placement for Membrane. The tack coat shall be applied to the existing surface using one of the following methods.
 - (1) A hand held wand with a nozzle that produces a fan shaped spray to apply the tack coat evenly according to the rate specified by the manufacturer.

- (2) A hand held wand without a spray nozzle. The tack coat shall be spread with a squeegee according to the rate specified by the manufacturer.
- (3) A distributor bar attached to a distributor truck, for longitudinal applications only. The distributor bar nozzles shall be set at 20 degrees to the axis of the bar and the tack coat shall be applied according to the rate specified by the manufacturer. Application of the tack coat directly from a distributor bar attached to a distributor truck will not be permitted for transverse applications.

The maximum width of the tack coat application shall be such that the tack coat extends a maximum of 1 1/2 in. (40 mm) on both sides of the stress relief membrane strip.

- (b) Stress Relief Membrane Placement. The open grid woven polyester side of the material shall be placed up with the nonwoven side placed into the tack. The stress relief membrane shall be centered over the crack or joint on the existing surface and with a minimum of 6 in. (150 mm) of the membrane extending beyond the edges of the joint.

The material shall be laid smooth with no uplifted edges. The stress relief membrane shall be placed and rolled immediately with a riding static drum roller or a rubber tire roller. A maximum of three minutes shall pass between the first and second rolling efforts.

The stress relief membrane shall be butted where transverse and longitudinal joints meet or where two rolls must be joined. When required, the stress relief membrane shall be cut with a razor knife from the woven polyester side.

The stress relief membrane shall be placed at least two hours in advance of paving operations. If application must immediately precede the paving operation, hot-poured joint sealer may be required as a tack coat to bond the stress relief membrane to the existing surface.

- (c) Traffic Exposure. Exposing the membrane to traffic shall be minimized. Small amounts of washed sand may be used to blot excess tack coat when necessary to facilitate movement of traffic or construction equipment over the membrane prior to placement of the overlay. Damaged membranes shall be removed and replaced.
- (d) Paving Tack Coat/Paving. Paving operations shall only begin when the membrane is thoroughly bonded to the existing surface. The membrane may be exposed to moisture and rain prior to the application of the overlay, however, the stress relief membrane must be dry at the time the overlay is placed.

A tack coat shall be applied prior to paving over the membrane. Hot-mix asphalt or dry washed sand may be broadcast ahead of the paver if the membrane is sticking to the tires of the paving equipment. The minimum asphalt overlay thickness (total) shall be 2 in. (50 mm) compacted.

When using a vibratory roller for compaction, it shall be set to the lowest amplitude and highest frequency settings.

443.10 Method of Measurement. Area reflective crack control treatment will be measured for payment in place and the area computed in square yards (square meters). Strip reflective crack control treatment will be measured for payment in feet (meters) along the joint or crack.

443.11 Basis of Payment. This work will be paid for at the contract unit price per square yard (square meter) for AREA REFLECTIVE CRACK CONTROL TREATMENT or per foot (meter) for STRIP REFLECTIVE CRACK CONTROL TREATMENT.

SECTION 444. FIBERGLASS FABRIC REPAIR SYSTEM

444.01 Description. This work shall consist of the installation of a fiberglass fabric repair system prior to placement of a hot-mix asphalt overlay.

444.02 Materials. Materials shall be according to Section 1063.

444.03 Equipment. Equipment shall consist of suitable sweepers, air compressors, hand brooms, pouring buckets, rubber-edged squeegees, cutting knives, and melting kettles. All hand tools shall be in a clean condition. Melting kettles shall be propane heated and have a temperature controlling thermostat. The melting kettle shall be clean and free from other bituminous materials which might change the properties of the bituminous adhesive. Since the adhesive is melted and used at higher temperatures than ordinary bituminous paving material, safety procedures concerning fire hazards and skin burns shall be observed.

CONSTRUCTION REQUIREMENTS

444.04 General. The existing pavement shall be dry and clean. All base failures shall be repaired and all cracks, spalls, potholes, or other depressions shall be sealed with an approved crack sealer or primed and filled with leveling binder (hand method) according to Section 406. The repair system shall be applied only when the ambient and pavement temperatures are at least 50 °F (10 °C) and rising.

Cleaning shall be accomplished by suitable sweepers, compressed air, or hand brooms. The bituminous adhesive, heated to 375 °F \pm 25 °F (190 °C \pm 15 °C), shall be applied by means of a hand spray bar or a pouring bucket and squeegee. The adhesive shall be squeegeed with sufficient uniformity to prevent streaking or ridging and shall extend a minimum of 1 in. (25 mm) beyond all edges of the fiberglass fabric. The fiberglass fabric shall be immediately placed on the adhesive. The material shall overlap adjacent fabric a minimum of 2 in. (50 mm). The fabric strips shall be free of wrinkles. Additional adhesive shall be squeegeed on top of the fabric and shall extend a minimum of 1 in. (25 mm) beyond all its edges. The application rate for two coats of bituminous adhesive in the system shall be a minimum of 0.70 gal/sq yd (3 L/sq m). When proper thickness is achieved, the weave pattern of reinforcement fabric shall be detectable through the top coat of the adhesive.

Art. 444.04 Removal and Replacement of Preformed Elastomeric

The repair system may be opened to construction traffic after a 30 minute minimum set time. Any fabric damaged shall be replaced prior to overlaying.

444.05 Method of Measurement. This work will be measured for payment in place and the area computed in square yards (square meters) of fabric surface. No allowance will be made for the fabric overlaps or the minimum extension of bituminous material beyond the edges of the fabric.

444.06 Basis of Payment. This work will be paid for at the contract unit price per square yard (square meter) for FIBER GLASS FABRIC REPAIR SYSTEM.

Leveling binder (hand-method) will be paid for according to Article 406.14.

SECTION 445. RESERVED

SECTION 446. RESERVED

SECTION 447. RESERVED

SECTION 448. RESERVED

SECTION 449. REMOVAL AND REPLACEMENT OF PREFORMED ELASTOMERIC JOINT SEALS FOR PAVEMENT

449.01 Description. This work shall consist of removing the existing joint seal and replacing it with a new preformed elastomeric joint seal.

449.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Preformed Elastomeric Joint Seals for Pavement	1053.01

449.03 Equipment. The machine used to cut the joints shall be an approved concrete saw.

CONSTRUCTION REQUIREMENTS

449.04 Preparation. The existing joint shall be removed and the joint reshaped to the dimensions shown on the plans. The edges shall be beveled to a smooth surface by either a cutting or grinding device attached to the saw blade following the sawing operation.

449.05 Installation. The joint shall be thoroughly cleaned prior to sealing. When the joint is free of foreign material and dry, the preformed elastomeric joint seal shall be installed by an approved machine method so that no twisting, rolling, or

misalignment with the opposite top edge occurs. The joint shall be sealed across the full width of the entire pavement with one piece of seal material. The seal shall be secured in place with a lubricant-adhesive applied to both sides of the seal or both faces of the concrete. Any adhesive on the top of the seal shall be removed. The seal shall be installed in a compressed condition below the bottom of the beveled edge and within 5/16 in. (8 mm) of the surface of the pavement.

449.06 Tolerances. During installation, the joint seal material will be checked for stretching and compression by pre-marking the length and width of the seal prior to installation. The stretch and compression tolerances shall be as follows.

- (a) Stretch. The joint seal material may be stretched five percent or less.
- (b) Compression. The joint seal material may be compressed two percent or less.

Once sealing operations have started, one joint per every twenty-five will be checked for stretch and compression. If an unsatisfactory condition is found, that seal and the seals on either side shall be removed until the condition disappears and the affected joints shall be replaced.

449.07 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirement for use of contract quantities shall be according to Article 202.07(a).
- (b) Measured Quantities. This work will be measured for payment in feet (meters), measured along the joint.

449.08 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for REMOVAL AND REPLACEMENT OF PREFORMED ELASTOMERIC JOINT SEALS FOR PAVEMENT.

SECTION 450. RELIEF JOINT

450.01 Description. This work shall consist of constructing a relief joint in existing pavement.

450.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Hot-Poured Joint Sealer	1050.02
(b) Preformed Expansion Joint Fillers	1051.09

450.03 Equipment. Equipment shall be according to the following.

- (a) Concrete Saw. The concrete saw shall be equipped with a diamond blade of sufficient size to saw pavements full-depth and be capable of accurately maintaining cutting depth and alignment.

- (b) Wheel Saw. The wheel saw shall be equipped with carbide tipped rotating cutters and be capable of accurately maintaining cutting depth and alignment.

CONSTRUCTION REQUIREMENTS

450.04 General. The relief joint shall be formed by full-depth sawing of the existing pavement with a concrete saw or a wheel saw. The joint shall be straight and perpendicular to the centerline, with a tolerance of 1 1/2 in. in 12 ft (40 mm in 3.6 m).

Prior to installing the preformed expansion joint filler, the sawed faces of the pavement shall be cleaned with compressed air. If the sawing operation disturbs or displaces the subbase, the disturbed subbase shall be removed and replaced with compacted FA 1 or FA 2 to the bottom of the existing pavement.

The preformed expansion joint filler shall be installed in a compressed condition in the sawed joint. The method used shall minimize damage to the filler.

The hot-poured joint sealer shall be installed as shown on the plans and in the saw cut extensions created by the concrete saw. The hot-poured joint sealer shall be placed according to Article 420.12. The joint sealer shall cure to the satisfaction of the Engineer prior to opening to traffic.

Wheel saw cut extensions or other large areas removed from the shoulders shall be replaced with the same material as in the existing shoulder before opening to traffic.

Excess material shall be disposed of according to Article 202.03.

450.05 Method of Measurement. This work will be measured for payment in feet (meters) along the joint from edge to edge of pavement.

450.06 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for RELIEF JOINT, of the width specified. If the sawed joint closes and the Engineer requires resawing the joint, this resawing will be paid for according to Article 109.04.

SECTION 451. CRACK SEALING HOT-MIX ASPHALT PAVEMENT

451.01 Description. This work shall consist of routing, cleaning, and sealing transverse and longitudinal reflected cracks in existing hot-mix asphalt (HMA) pavement.

451.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Hot-Poured Joint Sealer	1050.02

451.03 Equipment. The routing machine shall have a steel, circular cutting head with carbide tipped cutters mounted radially. The machine shall be capable of routing a uniform, square shape approximately 3/4 x 3/4 in. (20 x 20 mm) in either a straight or irregular line.

The kettle used for heating the sealer shall be double-jacketed.

CONSTRUCTION REQUIREMENTS

451.04 General. Primary transverse and longitudinal working cracks shall be routed, cleaned, and sealed. Any adjacent secondary cracks shall be only cleaned and sealed as directed by the Engineer.

Cracks shall be routed following the crack as nearly as possible, approximately 3/4 in. (20 mm) wide by 3/4 in. (20 mm) deep as close to a 1:1 ratio as possible. Immediately ahead of sealer placement, dust and debris shall be blown from the crack with a power brush/blower or with compressed air with a minimum pressure of 90 psi (620 kPa). When compressed air is used, the pneumatic tool lubricator must be bypassed and a filter installed on the discharge valve to keep water and oil out of the lines.

The hot-poured joint sealer shall be continuously and mechanically agitated during heating. The sealer shall be applied using the methods and equipment recommended by the manufacturer, except it shall only be placed when the air temperature in the shade is 40 °F (5 °C) or greater.

Existing raised reflective pavement markers shall be protected during the crack sealing operations. Tracking of sealant material will not be allowed. If sealant materials are applied to the markers, such material shall be removed.

Sealant shall be placed in the clean, dry crack. The crack shall be slightly overfilled and immediately squeegeed to provide a "band-aid" type effect approximately 2 in. (50 mm) wide, flush with the pavement surface, and with the edges feathered out.

The sealant shall be allowed to cure before opening to traffic. When approved by the Engineer, the sealant may be dusted with fine sand, portland cement, or mineral filler to prevent tracking.

451.05 Method of Measurement. This work will be measured for payment as follows.

- (a) Crack Routing. Routed cracks will be measured for payment in feet (meters) along the routed crack.
- (b) Crack Filling. Filling of cracks will be measured for payment in pounds (kilograms) of sealant used. The quantity of sealant used will be determined by counting the containers of sealant used, multiplied by the indicated pounds (kilograms) of each container.

Art. 451.06 Crack and Joint Sealing Portland Cement Concrete Pavement

451.06 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for CRACK ROUTING (PAVEMENT) and per pound (kilogram) for CRACK FILLING.

SECTION 452. CRACK AND JOINT SEALING PORTLAND CEMENT CONCRETE PAVEMENT

452.01 Description. This work shall consist of routing, cleaning, and sealing longitudinal shoulder joints, transverse and longitudinal random cracks, centerline joints, contraction joints, and transverse expansion joints in portland cement concrete pavement.

452.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Hot-Poured Joint Sealer	1050.02

452.03 Equipment. The routing machine shall have a steel, circular cutting head. The machine shall be capable of routing a uniform, square shape approximately 3/4 x 3/4 in. (20 x 20 mm) in either a straight or irregular line.

The concrete saw shall have a diamond tipped saw blade that will reface and widen the joint a maximum of 1/8 in. (3 mm).

The kettle used for heating the sealer shall be double-jacketed.

CONSTRUCTION REQUIREMENTS

452.04 General. The longitudinal shoulder joint between the edge of pavement and the newly placed hot-mix asphalt (HMA) shoulder, the transverse and longitudinal random cracks in other than continuously reinforced portland cement concrete pavement, contraction joints and the centerline joints shall be routed or sawed to approximately 3/4 in. (20 mm) wide by 3/4 in. (20 mm) deep as close to a 1:1 ratio as possible. When routing or sawing the longitudinal shoulder joint, the router or saw used shall be capable of following the path of the joint without causing excessive spalling or damage to the adjacent rigid pavement. If old sealants are present in the joint or crack, they shall be removed prior to routing or sawing.

Immediately ahead of the sealer placement, dust and debris shall be blown from the joint or crack with a power brush/blower or with compressed air at a minimum pressure of 90 psi (620 kPa). When compressed air is used, the pneumatic tool lubricator must be bypassed and a filter installed on the discharge valve to keep water and oil out of the lines.

The hot-poured joint sealer shall be continuously and mechanically agitated during heating. The sealer shall be applied using the methods and equipment recommended by the manufacturer, except it shall only be placed when the air temperature in the shade is 40 °F (5 °C) or greater.

Areas along the longitudinal shoulder joint, the transverse and longitudinal random cracks (where applicable), the contraction joint, or centerline where a void exists that exceeds 3/4 in. (20 mm) depth shall be provided with a backer rod to control the depth of sealant. The void shall be routed (if necessary) to provide a depth from the top of the backer rod to the top of the pavement of 3/4 in. (20 mm).

The areas where backer rod will be required shall be as directed by the Engineer. The backer rod diameter shall be 1/8 in. (3 mm) wider than the routed joint. The backer rod shall be a closed-cell, plastic-foam, heat resistant, chemically inert, waterproof rod compatible with the sealant used.

Sealant shall be placed in the clean, dry crack or joint. The crack or joint shall be slightly overfilled and immediately squeegeed to provide a "band-aid" type effect approximately 2 in. (50 mm) wide, flush with the pavement surface, and with the edges feathered out.

The sealant shall be allowed to cure before opening to traffic. When approved by the Engineer, the sealant may be dusted with fine sand, portland cement, or mineral filler to prevent tracking.

The procedure for routing, cleaning, and sealing longitudinal random cracks will be the same as the longitudinal shoulder joint, except the crack reservoir shall be sealed flush rather than providing an over-sealed or "band-aid" type effect.

Transverse expansion joints shall be routed to create an approximate 1 in. (25 mm) deep reservoir. The walls of the joint shall be cleaned and refaced. The reservoir shall be filled flush with sealant.

Existing raised reflective pavement markers shall be protected during the crack or joint sealing operations. Tracking of sealant material will not be allowed. If sealant materials are applied to the markers, such material shall be removed.

452.05 Method of Measurement. This work will be measured for payment as follows.

- (a) Joint or Crack Routing or Sawing. Routed or sawed joints or cracks will be measured for payment in feet (meters) along the routed or sawed joint or crack.
- (b) Joint or Crack Filling. Filling of joints or cracks will be measured for payment in pounds (kilograms) of sealant used. The amount of sealant used will be determined by counting the containers or sealant used, multiplied by the indicated pounds (kilograms) of each container.

452.06 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for JOINT OR CRACK ROUTING (PC CONCRETE PAVEMENT AND SHOULDER) and JOINT OR CRACK ROUTING HOT-MIX ASPHALT SHOULDER; and per pound (kilogram) for JOINT OR CRACK FILLING.

Furnishing and installing backer rod when required by the Engineer will be paid for according to Article 109.04.

SHOULDERS

SECTION 480. EARTH SHOULDERS AND MEDIANS

480.01 Description. This work shall consist of constructing earth shoulders and medians.

CONSTRUCTION REQUIREMENTS

480.02 General. The shoulder and median shall be constructed with earth which is free from vegetation, roots, sod or other objectionable material. The shoulders and medians may be constructed and finished with a blade grader. The earth in shoulder and median areas shall be compacted as specified in Article 205.06, except that the earth in the area between curb or gutter and sidewalk shall be compacted in a manner meeting the approval of the Engineer. Prior to final blading and shaping of the shoulders and medians, they shall be rolled with a pneumatic-tired roller meeting the requirements of Article 1101.01.

480.03 Rigid Type Surfacing, Curb, Gutter, or Curb and Gutter. At locations where shoulders or medians are constructed adjacent to a portland cement concrete pavement, portland cement concrete base course, curb, gutter, or curb and gutter, placing of the earth for the shoulders or medians shall be completed and the earth compacted, shaped and finished to the lines, grades and cross sections shown on the plans after the surfacing, curb, gutter, or curb and gutter has been constructed.

480.04 Nonrigid Type Surfacing. At locations where shoulders or medians are constructed adjacent to nonrigid type surfacing such as aggregate base or surface course, or any hot-mix asphalt surface course not constructed on a portland cement concrete base course, the following shall apply.

- (a) When the Base or Surface Course is constructed in a trench. Before the material for the base or surface course is deposited, earth shall be roughed in for the shoulders. The earth shall be placed so that it will be possible to retain and compact the edges of the base or surface course. After the base or surface course has been constructed, the balance of the earthwork required to complete the shoulders and median shall be performed, and the shoulders and median shall be shaped and trimmed to the lines, grades and cross sections shown on the plans.
- (b) When the Base or Surface Course is not constructed in a trench. Before the base or surface course is constructed, the earthwork required to complete the shoulders and median shall be shaped and trimmed to the lines, grades and cross sections shown on the plans.

480.05 Basis of Payment. This work will not be measured or paid for separately.

SECTION 481. AGGREGATE SHOULDERS

481.01 Description. This work shall consist of furnishing, placing, shaping, and compacting aggregate on a prepared subgrade adjacent to the edges of the completed pavement structure or stabilized shoulder.

481.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate	1004.04
(b) RAP Material (Note 1)	1031

Note 1. Reclaimed asphalt pavement (RAP) may be used as aggregate wedge shoulders Type B.

481.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Tamping Rollers	1101.01
(b) Pneumatic-Tired Rollers	1101.01
(c) Three-Wheel Rollers (Note 1)	1101.01
(d) Tandem Rollers (Note 1)	1101.01
(e) Vibratory Machine (Note 2)	
(f) Aggregate Spreaders	1102.04

Note 1. Three-wheel or tandem rollers shall weigh from 6 to 10 tons (5.5 to 9 metric tons) and not less than 200 lb/in. (35 N/mm) nor more than 325 lb/in. (55 N/mm) of width of roller.

Note 2. The vibratory machine shall meet the approval of the Engineer.

CONSTRUCTION REQUIREMENTS

481.04 Subgrade Preparation. The subgrade shall be prepared in a manner approved by the Engineer.

481.05 Moisture Content. Prior to being placed on the subgrade, the aggregate shall contain sufficient moisture to provide satisfactory compaction.

For Type A shoulders, the water and aggregate shall be mixed through a controlled aggregate mixing system. The system shall consist of a mechanical mixing device and aggregate and water measuring devices, meeting the approval of the Engineer. Wetting the aggregate in cars, bins, stockpiles, or trucks will not be permitted.

481.06 Aggregate Shoulders Type A and Type B. The shoulders shall be constructed in lifts of not more than 6 in. (150 mm) thick when compacted, except that if tests indicate the desired results are being obtained, the compacted thickness of any lift may be increased to a maximum of 8 in. (200 mm). The aggregate shall be placed with a spreader.

Each lift of material shall be compacted with a tamping roller, a pneumatic-tired roller, a vibratory machine, or a combination of any of the three, until the compaction has been approved by the Engineer. If the moisture content of the material is not such as to permit satisfactory compaction during the compacting operations, water shall be added in such quantity that satisfactory compaction can be obtained. The top lift shall be given a final rolling with a three-wheel or tandem roller.

If any subgrade material is worked into the aggregate during the compacting or finishing operation, all granular material within the affected area shall be removed and replaced with new aggregate.

The shoulders shall be constructed to the thicknesses shown on the plans. Thickness determinations shall be made at such points as the Engineer may select. When the constructed thicknesses are less than 90 percent of the thicknesses shown on the plans, aggregate shall be added to obtain the required thicknesses; however, the surface elevation of the completed shoulders shall not exceed by more than 1/8 in. (3 mm) the surface elevation shown on the plans or authorized by the Engineer.

481.07 Aggregate Wedge Shoulders, Type B. Prior to placing the aggregate wedge shoulder, Type B, the weeds and grass on the area to be covered shall be cut. The aggregate shall be deposited in its final position with a spreader and compacted to the satisfaction of the Engineer. If the moisture content of the aggregate is not such as to permit satisfactory compaction during the rolling operations, water shall be added in such quantity that satisfactory compaction can be obtained.

481.08 Opening to Traffic. The road shall be open to traffic according to Article 701.07.

481.09 Method of Measurement. This work will be measured for payment in tons (metric tons), cubic yards (cubic meters), or square yards (square meters) according to Article 311.08, except payment will not be made for aggregate outside the plan width.

481.10 Basis of Payment. This work will be paid for at the contract unit price per ton (metric ton) or per cubic yard (cubic meter) for AGGREGATE SHOULDERS, TYPE A, or AGGREGATE SHOULDERS, TYPE B; at the contract unit price per ton (metric ton) for AGGREGATE WEDGE SHOULDER, TYPE B; or at the contract unit price per square yard (square meter) for AGGREGATE SHOULDERS, TYPE A, or AGGREGATE SHOULDERS, TYPE B, of the thickness specified.

SECTION 482. HOT-MIX ASPHALT SHOULDERS

482.01 Description. This work shall consist of constructing a hot-mix asphalt (HMA) shoulder on a prepared subgrade, existing paved shoulder, or subbase.

482.02 Materials. Materials shall be according to Section 1030.

The amount of asphalt binder used in the top lift shall be increased 0.5 percent more than that required in the mix design, except when the HMA binder and surface course mixture option is used.

482.03 Equipment. The equipment shall be according to Article 312.04.

CONSTRUCTION REQUIREMENTS

482.04 General. For pavement and shoulder resurfacing projects, HMA binder and surface course mixtures the same as that specified for the mainline pavement may be used in lieu of HMA shoulder mixture for the resurfacing of shoulders, at the option of the Contractor.

For the construction of shoulder strips for pavement resurfacing, HMA binder and surface course mixtures the same as that specified for the mainline pavement shall be used.

HMA shoulders shall not be placed on frozen or muddy subgrade.

Whenever HMA shoulders are constructed adjacent to a pavement constructed on an improved subgrade and additional material is needed to extend the improved subgrade to the bottom of the HMA shoulder, the additional material shall be subbase granular material, Type C, according to Section 311.

482.05 Placing and Compacting. This work shall be accomplished according to Article 312.05, except the following.

The maximum thickness of the top lift shall be 3 in. (75 mm).

- (a) When the shoulder width is 10 ft (3 m) or greater, the top lift shall be placed with a spreading and finishing machine.
- (b) All other lifts shall be placed with a mechanical spreader approved by the Engineer. The machine shall be operated on the mainline pavement.
- (c) Immediately after each lift is placed, it shall be compacted with a vibratory roller and a tandem roller.

When the HMA binder and surface course mixture option is used on resurfacing projects, shoulder resurfacing widths of 6 ft (1.8 m) or less may be placed simultaneously with the adjacent traffic lane for both the binder and surface courses. The specified density, thickness and cross slope of the pavement and shoulder shall be met. The paver shall operate with both tracks/drive wheels on the traffic lane.

Shoulder resurfacing greater than 6 ft (1.8 m) in width shall be placed in a separate operation.

The HMA binder course portion of shoulder strips constructed simultaneously with pavement resurfacing may be constructed in one or two lifts. If the plans call for the pavement to be resurfaced with HMA surface course only, the entire shoulder strip may be constructed with surface course, except that the portion normally constructed with HMA binder course shall be placed and compacted separately.

482.06 Tolerance in Thickness. The shoulder shall be constructed to the thickness shown on the plans. When the contract includes square yards (square meters) as the unit of measurement for HMA shoulder, thickness determinations shall be made according to Article 407.10(b)(3) and the following.

- (a) Length of the Units. The length of a unit shall be a continuous strip of shoulder 2500 ft (750 m) long.
- (b) Width of the Units. The width of the unit shall be the full width of the shoulder.
- (c) Thickness Deficient by More than Ten Percent. When a core shows the shoulder to be deficient by more than ten percent of plan thickness, additional cores shall be taken on each side of the deficient core, at stations selected by the Contractor and offsets selected by the Engineer, to determine the limits of the deficient shoulder. No core shall be located within 5 ft (1.5 m) of a previous core obtained for thickness determination. The first acceptable core obtained on each side of a deficient core will be used to determine the length of the deficient shoulder. An acceptable core is a core with a thickness of at least 90 percent of plan thickness. The area of deficient shoulder will be defined using the length between two acceptable cores and the full width of the unit. The area of deficient shoulder shall be brought to specified thickness by the addition of the applicable mixture, at no additional cost to the Department and subject to the lift thickness requirements of Article 312.05, or by removal and replacement with a new mixture. However, the surface elevation of the completed shoulder shall not exceed by more than 1/8 in. (3 mm) the surface elevation of the adjacent pavement. When requested in writing by the Contractor, the Engineer may permit in writing such thin shoulder to remain in place. When an area of thin shoulder is left in place, and no additional lift(s) are placed, no payment will be made for the thin shoulder. In addition, an amount equal to two times the contract unit price of the shoulder will be deducted from the compensation due the Contractor.

When an area of deficient shoulder is removed and replaced, or additional lifts are placed, the corrected pavement shall be retested for thickness.

- (d) Right of Discovery. When the Engineer has reason to believe any core location does not accurately represent the true conditions of the work, he/she may order additional cores. When the additional cores, ordered by the Engineer, show the shoulder to be at least 90 percent of plan thickness, the additional cores will be paid for according to Article 109.04. When the

additional core shows the shoulder to be less than 90 percent of plan thickness, the procedure in (c) above shall be followed.

482.07 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. When HMA shoulders are constructed along the edges of the completed pavement structure, HMA shoulders will be measured for payment in place and the area computed in square yards (square meters). The width for measurement will be from the edge of the pavement to the top edge of the HMA shoulder as shown on the plans or as directed by the Engineer.

On pavement and shoulder resurfacing projects, HMA shoulders will be measured for payment in tons (metric tons) according to Article 406.13, except that the requirement that payment will not be made for any HMA mixture in excess of 103 percent of the quantity specified by the Engineer will not apply. When shoulder resurfacing is placed simultaneously with the adjacent traffic lane or when a HMA wedge is placed simultaneously with the binder course on the traffic lane as specified in Article 406.10, the quantity of HMA shoulders will be measured for payment as specified in Article 406.13.

The HMA binder and surface course mixtures used in construction of shoulder strips for pavement resurfacing will be measured for payment in tons (metric tons) as specified in Article 406.13, except that the thickness of surface course will be limited to that specified for the adjacent resurfacing. Surface course used in excess of this amount will be measured for payment as binder course.

Subbase granular material Type C, will be measured for payment according to Article 311.08.

482.08 Basis of Payment. When HMA shoulders are constructed along the edges of the completed pavement structure, this work will be paid for at the contract unit price per square yard (square meter) for HOT-MIX ASPHALT SHOULDERS of the thickness specified. The specified thickness shall be the thickness shown on the plans at the edge of the pavement.

Subbase granular material Type C will be paid for according to Article 311.09.

On pavement and shoulder resurfacing projects, the shoulder resurfacing will be paid for at the contract unit price per ton (metric ton) for HOT-MIX ASPHALT SHOULDERS.

The construction of shoulder strips for resurfacing pavements will be paid for as hot-mix asphalt binder or surface course, according to Section 406.

SECTION 483. PORTLAND CEMENT CONCRETE SHOULDERS

483.01 Description. This work shall consist of constructing portland cement concrete shoulders on a prepared subgrade or subbase.

483.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Tie Bars	1006.10
(c) Poured Joint Sealers	1050
(d) Protective Coat	1023.01

483.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Forms	1103.05
(b) Formless Paver	1103.16
(c) Miscellaneous Equipment	1103.17

CONSTRUCTION REQUIREMENTS

483.04 General. Except for Article 420.10, portland cement concrete shoulders shall be constructed according to the applicable portions of Articles 420.04 through 420.18.

Whenever concrete shoulders are constructed adjacent to a pavement constructed on an improved subgrade and additional material is needed to extend the improved subgrade to the bottom of the concrete shoulder, the additional material shall be subbase granular material, Type C, according to Section 311.

483.05 Placing and Finishing. The pavement edge at all transverse joints shall be sealed or caulked to prevent the intrusion of mortar from the shoulder placing operation into the joint.

If the placement of concrete shoulders requires mechanical equipment to operate on the adjacent lane of pavement, that lane shall have attained the strength specified for 14 day concrete. If only finishing equipment is to be operated on the edge of the adjacent lane, shoulder placement may be permitted after three days.

When forms are used, they shall be set and removed according to Articles 420.06 and 420.11, respectively. A mechanical spreader and finishing machine will not be required. The concrete may be struck off and consolidated using a vibrating screed approved by the Engineer.

When the slip form method is used, the slip form paving equipment may operate from the adjacent lane or on tracks spanning the shoulder area. The slip form equipment shall vibrate the concrete either externally or internally with sufficient intensity to consolidate the concrete throughout its entire depth and width. The concrete shall be consolidated and finished true to grade and cross section in one

pass in a manner such that a minimum of hand floating will be required. The tolerance for edge slump shall be according to Article 420.14(c).

Prior to the final finish, the shoulder shall be straightedge tested and corrected according to Article 420.09(c). When forms are used, the outer edge of the shoulder shall be finished with an edging tool. The final finish shall be according to Article 420.09(e)(1).

483.06 Joints. Joints shall be constructed as shown on the plans and as follows.

- (a) Longitudinal Construction Joint. Tie bars shall be placed and the sealant reservoir shall be constructed according to Article 420.05(b). The joint shall be sealed according to Article 420.12.
- (b) Transverse Contraction and Transverse Expansion Joints. Contraction and expansion joints shall be constructed in line with the contraction and expansion joints in the adjacent pavement.
- (c) Transverse Construction Joints. When the shoulder contraction joints are spaced at 20 ft (6.1 m) or less, the transverse construction joints shall be located at a contraction or expansion joint.

When the shoulder contraction joints are spaced greater than 20 ft (6.1 m), transverse construction joints shall be located either midway between shoulder contraction joints or at shoulder contraction joints.

483.07 Tolerance in Thickness. The shoulder shall be constructed to the thickness shown on the plans. Thickness determinations shall be made according to Article 482.06, except the option of correcting deficient pavement with additional lift(s) shall not apply.

483.08 Opening to Traffic. The shoulders shall be open to traffic according to Article 701.17(a).

483.09 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. This work will be measured for payment in place and the area computed in square yards (square meters). The width for measurement will be from the edge of the pavement to the edge of the portland cement concrete shoulder as shown on the plans or as directed by the Engineer.

The area of shoulder upon which the protective coat is applied will be measured for payment in place and the area computed in square yards (square meters).

Subbase granular material, Type C, will be measured for payment according to Article 311.08.

483.10 Basis of Payment. This work will be paid for at the contract unit price per square yard (square meter) for PORTLAND CEMENT CONCRETE SHOULDERS, of the thickness specified. The specified thickness shall be the thickness shown on the plans at the edge of the pavement.

If a protective coat is applied, it will be paid for at the contract unit price per square yard (square meter) for PROTECTIVE COAT.

Subbase granular material, Type C, will be paid for according to Article 311.09.

DIVISION 500. STRUCTURES**BRIDGES****SECTION 501. REMOVAL OF EXISTING STRUCTURES**

501.01 Description. This work shall consist of the removal of existing traffic and drainage structures or portions thereof.

CONSTRUCTION REQUIREMENTS

501.02 General. The Contractor shall submit a demolition plan to the Engineer for approval, including the proposed methods of demolition and the location(s) and type(s) of equipment to be used, for the removal of existing bridge structures or bridge decks (with the exception of box culverts), when such work will be adjacent to or over an active roadway, railroad, or waterway designated on the plans as "Public Waters". The demolition plan shall include an assessment of the structure condition and an evaluation of the capacity and stability of the structure during demolition and shall be sealed by an Illinois Licensed Structural Engineer.

Materials that are to be salvaged under the contract and which the Engineer deems fit for reuse shall be carefully removed in transportable sections and stockpiled near the site at a location designated by the Engineer. If the material for reuse is unfit, through no fault of the Contractor, the material shall be disposed of according to Article 202.03. When the Contractor damages or destroys such material, the Contractor shall repair or replace the material in a manner satisfactory to the Engineer. Materials that are not to be salvaged shall be removed and disposed of according to Article 202.03.

When a superstructure is specified to be salvaged for reerection, all members and loose parts shall be properly matchmarked, all machined steel surfaces treated with an approved anti-rust compound, and all loose parts wired to adjacent members or packed in marked boxes.

501.03 Protective Shield System. When required, a protective shield system shall be erected and maintained to protect pedestrian, vehicular, or railroad traffic from falling objects. The system shall protect the bridge length shown on the plans. The width to be protected shall be the out-to-out width of the existing structure, unless otherwise shown on the plans. The protective shield system shall be designed and constructed to sustain loads of 200 lb/sq ft (9.5 kPa) in addition to its own weight. Protective shield systems comprised of wood members shall be designed for a minimum loading duration of seven days. The system may be either fixed or mobile. The existing vertical clearances above roadways and/or railroad tracks shall be maintained. The Contractor shall coordinate the installation with municipalities and/or utilities to insure protection of their facilities during the removal process.

The Contractor shall submit working drawings and calculations prepared and sealed by an Illinois Licensed Structural Engineer to the Engineer for the protective shield system. The drawings shall provide full details, dimensions, and types of

materials proposed for use. The protective shield system shall not be installed until authorization to proceed is given by the Engineer.

Concrete removal shall not commence until the protective shield system is in place and in conformity with the sealed working drawings.

Upon completion of the work or when directed by the Engineer, the protective shield system shall be removed.

501.04 Complete Removal of Structures. Existing structures shall be removed to at least 1 ft (300 mm) below the proposed elevation of subgrade or ground surface. Portions of existing structures below this elevation that interfere with the proposed construction shall also be removed.

When slope wall is specified to be removed, it shall be the responsibility of the Contractor to determine the thickness of the slope wall to be removed and the extent to which it is reinforced. No additional compensation will be allowed because of variations from the assumed thickness or from the thickness shown on the plans, or for variations in the amount of reinforcement.

Removal of existing pipe culverts shall include any headwalls, wingwalls, or aprons attached to the culvert.

501.05 Partial Removal of Structures. Where portions of existing structures are to remain in service, portions to be removed shall be removed in such a manner as to leave the remaining structure undamaged and in proper condition for the use contemplated. Any damage to the portions remaining in service shall be repaired. Repairs shall be made as directed by the Engineer. The removed portions shall be disposed of according to Article 202.03.

Prior to partial removal of any concrete structure, a 3/4 in. (20 mm) deep saw cut shall be made along all boundaries of removal areas adjacent to areas to remain in place.

Where existing bars are to extend from the remaining portions of existing structures into new construction, the concrete shall be removed so as to leave the projecting bars clean and undamaged. All newly exposed concrete and exposed reinforcement bars to be incorporated into new concrete shall be blast-cleaned; epoxy coated reinforcement bars shall be cleaned and repaired according to Article 508.04. Where projecting bars are not to extend into the new construction, they shall be cut off flush with the surface to which the old concrete has been removed.

Additional requirements for the partial removal of specific structures shall be as follows.

- (a) **Bridge Decks, Partial Removal.** When utilizing hammers to perform partial removal within 1 ft (300 mm) of the saw cut boundaries or portions of the existing bridge deck to remain in service, the hammers shall be limited to 15 lb (7 kg) chipping hammers or hand tools. Particular care shall be exercised at the bottom of the slab to avoid breakage beyond the designated removal line. When jack hammers are utilized to remove the remaining

concrete, the hammers shall not be heavier than the nominal 45 lb (20 kg) class. More powerful hydraulic impact equipment will not be allowed to perform this removal. The surfaces presented as a result of this removal shall be reasonably true and even, with sharp straight corners that will permit a neat and workmanlike joint with the new construction.

Upon removal of the formwork, the bottom surfaces of new concrete, adjacent to remaining portions of existing concrete, shall be inspected with hammer sounding to detect loose and delaminated areas. Those areas shall be removed as directed by the Engineer. All removed areas 1 in. (25 mm) or deeper shall be repaired with an approved method.

- (b) Bridge Decks, Complete Removal. The concrete within 1 ft (300 mm) of partial depth saw cut boundaries, stage removal lines, or attached to and/or supported by portions of the structure to remain in service shall be removed according to Article 501.05(a). When jackhammers or hydraulic impact equipment are utilized to remove the remainder of the concrete, the equipment shall have a maximum rated striking energy of 1200 ft lb (1600 J). When saw cutting of the deck is utilized for deck removal, the top flanges of all beams or girders shall be marked on the deck surface. Saw cutting directly over the top of beam or girder flanges may be permitted only if shown on the plans. The maximum saw cut depth allowed directly over a flange shall be to the bottom of the top mat of reinforcing steel but shall not exceed half the deck thickness. The Contractor shall provide positive control for controlling the depth of cut into the slab. The Contractor shall provide sawing equipment adequate in size and horsepower to complete the sawing operation.
- (c) Culverts. At locations designated by the Engineer, all earth and debris shall be removed from the invert of the portions of existing culverts which are to remain in service.
- (d) Substructures. When piers, abutments, or retaining walls, etc. or portions thereof are to be removed adjacent to structures or property to remain in use, even if that use is only temporary, the removal shall be done in such a manner as to not transmit damaging energy in to the remaining structure. The maximum rated impact energy shall be limited to 1200 ft lb (1600 J) unless the remaining portion of the structure can be fully isolated from the portion being removed. The removal shall be completed so as to maintain adequate structural and foundation support of the remaining elements.

At the Contractor's option, hydrodemolition equipment meeting the requirements of Article 1101.11 may be used. Operation of the hydrodemolition equipment shall be performed and supervised by qualified personnel certified by the equipment manufacturer. Evidence of certification shall be presented to the Engineer. When partial-depth removal is required, the equipment shall be calibrated and set to remove sound concrete to the required depth. If sound concrete is being removed below the required depth, the Engineer will require the equipment to be recalibrated and reset.

The Contractor shall control the runoff water generated by the various construction activities in such a manner as to minimize, to the maximum extent practicable, the discharge of construction debris into adjacent waters, and shall

properly dispose of the solids generated according to Article 202.03. Runoff water shall not be allowed to constitute a hazard on adjacent or underlying roadways, waterways, drainage areas, or railroads, nor be allowed to erode existing slopes.

501.06 Method of Measurement. When paid for as a separate item, removal of existing structures, removal of existing superstructures, removal of existing concrete deck, and removal of existing concrete headwall for pipe culverts will be measured for payment in units of each at the location designated on the plans.

The protective shield system will be measured for payment in place and the area computed in square yards (square meters). The length will be measured along the centerline of the structure. The width will be measured perpendicular to the centerline of the structure.

When paid for as a separate item, slope wall removal will be measured for payment in place and the area computed in square yards (square meters).

Removal of existing culverts will be measured for payment in place, in feet (meters) along the invert of the culvert.

When paid for as a separate item, removal of existing bridge rail will be measured in place in feet (meters). The length measured will be the overall length along the top longitudinal rail element through all posts and gaps. Removal and disposal of all posts and connecting hardware associated with the bridge rail will not be measured for payment.

When paid for as a separate item, the removal of concrete or masonry for partial removal of structures will be measured for payment in place and the volume computed in cubic yards (cubic meters).

Excavation of earth necessary to perform the removal of existing structures will not be measured for payment.

Rock excavation will be measured for payment according to Article 502.12.

501.07 Basis of Payment. When the contract contains a separate item for the removal of a structure, the work will be paid for at the contract unit price per each for REMOVAL OF EXISTING STRUCTURES, REMOVAL OF EXISTING SUPERSTRUCTURES, or REMOVAL OF EXISTING CONCRETE DECK at the location designated on the plans.

When the contract contains a separate item for the partial removal of concrete or masonry structures the work will be paid for at the contract unit price per cubic yard (cubic meter) for CONCRETE REMOVAL or MASONRY REMOVAL.

Disposal of materials specified for salvage but deemed unfit for further use through no fault of the Contractor will be paid for according to Article 109.04.

The protective shield system will be paid for at the contract unit price per square yard (square meter) for PROTECTIVE SHIELD.

Removal of existing pipe culvert concrete headwalls will be paid for at the contract unit price per each for CONCRETE HEADWALL REMOVAL.

Removal of existing pipe culverts will be paid for at the contract unit price per foot (meter) for PIPE CULVERT REMOVAL.

When a pay item is provided in the contract, removal of existing slope wall will be paid for at the contract unit price per square yard (square meter) for SLOPE WALL REMOVAL.

When a pay item is provided in the contract, removal of existing bridge rail will be paid for at the contract unit price per foot (meter) for BRIDGE RAIL REMOVAL.

When the Engineer directs that earth and debris be removed from culvert inverts, such removal will be paid for according to Article 109.04.

When existing structures or portions of existing structures are encountered which cannot be removed by normal excavation procedures and are not shown on the plans or are not evident in the field and are required to be removed, the cost of such removal will be paid for according to Article 109.04.

Rock excavation will be paid for according to Article 502.13.

SECTION 502. EXCAVATION FOR STRUCTURES

502.01 Description. This work shall consist of the excavation required for the construction of structures including bailing, draining, pumping, sheeting; the construction of cofferdams, or temporary cribs if found necessary, and their subsequent removal; and backfilling to the level of the ground surface as it existed before any excavation was made.

CONSTRUCTION REQUIREMENTS

502.02 Clearing, Tree Removal, and Protection of Existing Plant Material. Prior to starting excavation operations in any area, all clearing, tree removal, and protection of existing plant material in that area shall be performed as specified in Section 201.

502.03 General. Excavation for structures shall include all materials encountered, regardless of their nature.

Structure excavation shall include all excavation, except rock excavation or excavation within a cofferdam.

Cofferdam excavation shall include all excavation within the limits of a cofferdam, except rock excavation.

Rock excavation for structures shall consist of the excavation of boulders 1/2 cu yd (0.4 cu m) in volume or greater and all rock in ledges, bedded deposits, and conglomerate deposits exhibiting the physical characteristics and difficulty of rock

removal as determined by the Engineer. After the Engineer has made the determination that the material qualifies as rock excavation, the Contractor may use any method, approved by the Engineer, to remove the rock. Rock excavation for structures shall also include existing concrete, masonry, timber grillages, foundation piles, and similar materials which are not exposed to view, are not shown on the plans, and for which payment is not otherwise provided.

502.04 Sequence of Operations. The elevations of the bottoms of footings, as shown on the plans, shall be considered as approximate and the Engineer may order such changes in dimensions or elevations of footings as may be necessary to secure a satisfactory foundation. Where foundation piles are used, the excavation of each footing, as shown on the plans, shall be completed before the piles are driven. After the piles are driven, all loose and displaced material shall be removed to the bottom of the footing elevation.

502.05 Excavation in Rock. Where the footing excavation is in rock, the rock shall be excavated to the plan dimensions of the footing or seal coat. No rock shall project inside of such dimension more than 2 in. (50 mm). Other rock excavation shall be as necessary for the construction of the structure, subject to the limitations for measurement for payment specified in Article 502.12. All cracks, voids, seams, or other irregularities in the excavation shall be cleaned and filled with concrete.

502.06 Cofferdams. Cofferdams shall consist of watertight enclosures surrounding excavations. When cofferdams are not specified in the contract documents and conditions are encountered where the excavation for the structure cannot be kept free of water for prosecuting the work by pumping and/or diverting water by the use of sheeting or dikes, the Contractor, with the written permission of the Engineer, will be permitted to construct a cofferdam.

The cofferdams shall be designed, constructed, and removed with the Engineer's approval. Cofferdams shall consist of engineered structural components consisting of timber, standard steel sheet pile sections, structural steel sections, cylindrical metal shells, or a combination of the above. Earthen embankments or dikes will not be classified as cofferdams.

The Contractor shall submit drawings and design calculations showing the proposed design, method of construction, removal, as well as other details left open to choice or not fully detailed on the plans. The design and method of construction shall provide, within the measurement limits specified in Article 502.12, necessary clearance for forms, inspection of exterior of the forms, pumping, protection of fresh concrete from rising water, and protection of the footing from erosion. No component of the cofferdam shall extend into the substructure concrete without written permission of the Engineer. These drawings shall be prepared and sealed by an Illinois Licensed Structural Engineer and submitted to the Engineer and approved prior to the start of construction.

- (a) **Seal Coat.** Seal coats shall be constructed according to Article 503.14. When a cofferdam and seal coat are added to the contract by written permission of the Engineer, the design of the seal coat, including design calculations, shall be included in the overall design of the cofferdam when submitted to the Engineer for review and approval. When the excavation within the cofferdam has been completed and piles have been driven, the

elevation of the bottom of the cofferdam shall be determined by soundings. The equipment and methods used to conduct the soundings shall meet the approval of the Engineer. Any material higher than the plan elevation of the bottom of the seal coat shall be removed.

- (b) Removal. Removal shall be according to the previously approved procedure. Unless otherwise approved in writing by the Engineer, all components of the cofferdam shall be removed.

502.07 Excavation Other Than Rock. When the structure excavation occurs in material other than rock, the limits of the excavation shall not exceed the dimensions specified in Article 502.12. These limits may be exceeded only with the permission of the Engineer and subject to the limitations for measurement for payment specified in Article 502.12. The depth of the excavation shall be carried to the plan bottom of the footing elevation. If the material encountered at the plan bottom elevation of spread footings is soft, muddy, or otherwise unsuitable, the material shall be removed to an additional depth as directed by the Engineer and replaced with crushed stone, gravel or other material approved by the Engineer.

502.08 Pumping. Pumping from the interior of a foundation enclosure shall be done in a manner approved by the Engineer. Pumping will not be allowed during placement of the concrete or for a period of 24 hours after completion of the placement, unless the pumping is accomplished from a watertight sump separated from the concrete being placed. Pumping to dewater a sealed cofferdam shall not begin until the seal coat has attained the design strength.

502.09 Inspection. After each excavation is completed, the Contractor shall notify the Engineer. No concrete shall be placed until after the Engineer has approved the depth of the excavation and the character and condition of the foundation material. When ordered in writing by the Engineer, the bottom of the excavated space within any cofferdam in which a seal coat is to be constructed shall be inspected by a qualified diver.

502.10 Backfilling. Backfilling shall consist of placing and compacting the necessary fill within the space excavated for a structure below the ground surface as it existed before any excavation was made. Fill required above the ground surface as it existed prior to excavation for the structure shall be considered as embankment. Bracing, forms, and rubbish shall be removed from the excavation before the backfill is placed. Unless sheeting is to remain in place, it shall be removed at such time as directed by the Engineer to prevent loosening unexcavated material and facilitate placing and compacting the backfill. Sloping sides of the excavation shall be stepped or serrated to prevent wedging action of the backfill against the structure.

Where the original ground surface is higher than the proposed elevation of roadway surface, stream banks or channels, the backfill shall be constructed up to the elevation designated as the proposed ground surface.

Backfill which is to serve as a roadbed, or upon which embankment is to be placed, shall be constructed by materials satisfactory to the Engineer. No sod, frozen material, or any material which, by decay or otherwise, might cause settlement, shall be placed or allowed to remain in the backfill at such locations. Whenever the material obtained from the excavation is suitable, it may be used in constructing the

backfill. Excavated material that is unsuitable for backfill because it is in excess of 110 percent of the optimum moisture content shall be allowed to dry before being used as backfill. Excavated material unsuitable for backfill shall be disposed of according to Article 502.11. If the amount of suitable excavated material is insufficient, suitable material shall be obtained and used for making or completing the backfill.

In placing backfill or embankment, the material shall be placed simultaneously insofar as possible to approximately the same elevation on both sides of a wall, pier, or column. If conditions require placing backfill or embankment appreciably higher on one side of a wall, pier, or column than on the opposite side, the additional material on the higher side shall not be placed until test specimens show that the concrete has attained the required flexural strength and the curing period is completed. In the absence of tests to determine the flexural strength, the additional material on the higher side shall not be placed until at least 14 days have elapsed after the placing of the concrete, exclusive of days on which the temperature of the air surrounding the concrete falls below 45 °F (7 °C).

Backfill or embankment shall not be placed behind the walls of concrete culverts until the top slab is placed and cured. Backfill and embankment behind the sidewalls of culverts having a clear height of more than 5 ft (1.5 m), shall be carried up simultaneously, and at no time shall the fill be more than 2 ft (600 mm) higher than behind the opposite sidewall.

Backfill shall not be placed in water at closed abutments, culverts, or retaining walls. The excavated area around these structures shall be pumped dry, and any mud or loose material within the excavated area shall be removed before placing backfill. At piers, backfill may be placed in water, providing no roadway embankment or slope wall is to be supported by the backfill and provided that both the water level and backfill are kept at approximately the same elevation on opposite sides of the pier. A time interval, approved by the Engineer, shall elapse before placing additional fill on one side of the pier, above the water surface.

Mechanical compaction of backfill will not be required around piers upon which no roadway embankment, slope wall, or other highway appurtenance is to be placed; and at those locations that are not adjacent to a highway, railroad, or other improvement beneath the structure.

Except as specified, the procedures for placing and compacting the backfill shall be according to Articles 205.04, 205.05, and 205.06. Except as described above, all backfill shall be placed in continuous horizontal layers not more than 8 in. (200 mm) in thickness, loose measurement, and each layer shall be compacted with a mechanical tamper of a type approved by the Engineer before the next layer is placed, and the backfill shall be compacted to the density specified in Article 205.06. If the moisture content of the backfill material exceeds 110 percent of the optimum moisture content determined for this material, no additional material shall be placed without the permission of the Engineer.

A deposit of gravel or crushed stone, CA 5, CA 7, or CA 11, according to the gradation requirements of Article 1004.01, at least 2 ft (600 mm) in each direction shall be placed at the back of each drain hole in abutments, wingwalls, retaining walls, and culvert sidewalls. The bottom of this deposit shall be 2 in. (50 mm) below

the drain hole. All form boards or other obstructions shall be removed from the drains before such deposit is placed. The cubical deposit of coarse aggregate shall be completely enclosed in a fabric envelope. The fabric shall be according to the requirements of the applicable portions of Section 1080 and Section 282 with either the 6 or 8 oz/sq yd (200 or 270 g/sq m) material allowed. Free edges shall overlap by 12 in. (300 mm).

502.11 Disposal of Excess Excavation and Unsuitable Material.

Unsuitable material and suitable material in excess of that required for backfilling shall be disposed of according to Article 202.03.

502.12 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Structure excavation, when specified, will be measured for payment in its original position and the volume computed in cubic yards (cubic meters). Horizontal dimensions will not extend beyond vertical planes 2 ft (600 mm) outside of the edges of footings of bridges, walls, and corrugated steel plate arches. The vertical dimension for structure excavation will be the average depth from the surface of the material to be excavated to the bottom of the footing or seal coat as shown on the plans or ordered in writing by the Engineer. The volume of any unstable and/or unsuitable material removed within the structure excavation will be measured for payment in cubic yards (cubic meters).

Rock excavation for structures will be measured for payment as follows.

- (1) General. Rock excavation will be measured for payment in its original position and the volume in cubic yards (cubic meters) computed by the method of average end areas.
- (2) Footings and Seal Coats. Rock excavation for footings and seal coats will be measured for payment in its original position and the volume computed in cubic yards (cubic meters). Measurements will be taken vertically from the top of the rock to the elevation of the bottom of the rock or bottom of the structure, whichever occurs first, and horizontally within the perimeter of the structure to be placed.
- (3) Pipe Structures. Rock excavation for pipe structures will be measured for payment in its original position and the volume computed in cubic yards (cubic meters). Measurements will be taken vertically from the elevation of the top of the rock to the specified elevation below the bottom of the pipe and horizontally for the width of the trench specified for placing the pipe. When the depth of rock removal below the bottom of a pipe structure is not otherwise specified, the rock shall be removed to 8 in. (200 mm) below the bottom of the pipe; except for water service lines and pipe underdrains, the depth of removal shall be 3 in. (75 mm) below the bottom of the pipe.

Rock excavation for storm sewers which are jacked in place will be measured as the volume actually moved, except that the horizontal dimension will not be greater than the external diameter of the pipe plus 12 in. (300 mm) and the vertical dimension will not be greater than the external diameter of the pipe plus 12 in. (300 mm) above the pipe and 8 in. (200 mm) below the pipe, unless the total vertical dimension is less than 4 ft (1.2 m), in which case 4 ft (1.2 m) may be used.

- (4) Boulders, Concrete, or Timber. Boulders, concrete, or timber, 1/2 cu yd (0.4 cu m) or more in volume, will be measured for payment individually and the volume in cubic yards (cubic meters) computed from average dimensions taken in three directions. The quantity of concrete or timber to be paid for will be the volume of such material actually removed within the limits of the excavation as specified.
- (5) Sumps in Rock. Where it is necessary to construct sumps in rock, measurements shall include the areas and depths required for such sumps.

Cofferdam excavation will be measured for payment in cubic yards (cubic meters) in its original position within the cofferdam sheeting. The horizontal dimensions used in computing the volume will not extend beyond vertical planes 2 ft (600 mm) outside of the edges of the pier footings or 4 ft (1.2 m) outside of the faces of the pier wall whichever is greater. The vertical dimensions will be the average depth from the surface of the material to be excavated to the elevation shown on the plans for bottom of the footing or seal coat, or as otherwise determined by the Engineer as the bottom of the excavation.

502.13 Basis of Payment. Except as provided, the work specified in this Section will not be paid for as a separate item. Where excavation for structures is not specified, the cost of the excavation shall be considered as included in the contract unit price for the class of concrete involved, or other unit price item of the work for which it is required. Structure excavation, when specified, will be paid for at the contract unit price per cubic yard (cubic meter) for STRUCTURE EXCAVATION.

Cofferdam excavation will be paid for at the contract unit price per cubic yard (cubic meter) for COFFERDAM EXCAVATION. When the contract does not contain a pay item for cofferdam excavation and this item is required, it will be paid for according to Article 109.04.

Rock excavation for structures will be paid for at the contract unit price per cubic yard (cubic meter) for ROCK EXCAVATION FOR STRUCTURES. When the contract does not contain a pay item for rock excavation for structures and this item is required, it will be paid for according to Article 109.04.

Removal and disposal of unstable and/or unsuitable material will be paid for at the contract unit price per cubic yard (cubic meter) for REMOVAL AND DISPOSAL OF UNSUITABLE MATERIAL FOR STRUCTURES. When the contract does not contain a pay item for removal and disposal of unstable and/or unsuitable material for structures and this item is required, it will be paid for according to Article 109.04.

Where it is necessary to excavate below the plan bottom of footing elevation, the excavation will be paid for at the contract unit prices for the class of excavation involved. Furnishing and placing the crushed stone, gravel, or other material will be paid for according to Article 109.04.

Cofferdams, when specified, will be paid for at the contract unit price per each for COFFERDAMS, at the locations specified. When added to the contract, cofferdams will be paid for according to Article 109.04.

Tree removal and protection of existing plant material will be paid for according to Section 201.

Additional suitable material required for backfilling within the roadbed, will be paid for according to Article 109.04.

When ordered by the Engineer in writing, cofferdam inspection by a certified diver will be paid for according to Article 109.04.

SECTION 503. CONCRETE STRUCTURES

503.01 Description. This work shall consist of constructing cast-in-place concrete structures.

503.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Protective Coat	1023
(c) Preformed Expansion Joint Fillers	1051
(d) Waterproofing Materials	1060.01 - 1060.08
(e) Nonmetallic Water Seals	1054
(f) Reinforcement Bars	508
(g) Grout	1024.01

503.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Hand Vibrator	1103.17(a)
(b) Vibrating Screed	1103.17(g)
(c) Finishing Machine.....	1103.13(a)
(d) Fogging Equipment.....	1103.17(k)

CONSTRUCTION REQUIREMENTS

503.04 Excavation and Backfill. Excavation and backfill shall be according to Section 502. Substructures, foundations, and footings shall be constructed in open excavation wherever practicable.

503.05 Falsework. The falsework shall be designed, constructed, and maintained for the required loads and site conditions. The Contractor shall submit

detailed plans for falsework, prepared and sealed by an Illinois Licensed Structural Engineer, for examination by the Engineer. If such plans are not satisfactory to the Engineer, the Contractor shall make such changes in them as may be required.

For continuous concrete slab and cast-in-place concrete girder bridges, falsework shall be provided for the full length of each continuous unit and the full width of the structure.

For calculating the strength of falsework, a weight (mass) of 150 lb/cu ft (2400 kg/cu m) shall be assumed for the concrete. The design of the falsework shall take into account the weight of the concrete and also other loads incidental to the construction operations. All falsework shall be designed and constructed to provide the necessary rigidity and to support the imposed loads without appreciable settlement or deformation. The Contractor shall make allowance for the deflection, shrinkage, and settlement of falsework, in addition to the allowance for the amount of dead load deflection and camber shown on the plans. A method satisfactory to the Engineer shall be used to detect any settlement that may occur during the placing of the concrete.

Falsework bents shall be founded upon piling driven to a capacity sufficient to support the load without appreciable settlement. If the soil is firm and well compacted, the Contractor may, as an alternate, place falsework bents upon concrete footing or mud sills of sufficient size that the pressure on the soil will not exceed 1 1/2 tons/sq ft (145 kPa) or the Contractor may support falsework from the piers or abutments, provided sleeves for any tie bolts can be cast into the concrete. Sleeves or other appurtenances cast into the concrete shall be constructed so as to permit their removal to a depth of at least 1 1/2 in. (40 mm) from the face without injury to the concrete. Drilling into existing piers or abutments that are to remain as a part of the final structure will not be permitted for the support of falsework. The Engineer may require the Contractor to use screw jacks or hardwood wedges to take up any settlement in the form work, either before or during the placing of the concrete.

Falsework supporting forms for cast-in-place concrete shall remain in place until tests show that the concrete has attained the required flexural strength and the curing period is completed. In the absence of tests to determine the flexural strength, the falsework shall remain in place until at least 14 days have elapsed after the placing of the concrete, exclusive of days in which the temperature falls below 45 °F (7 °C). When either fly ash or ground granulated blast-furnace slag has been used in the concrete mixture, falsework shall remain in place a minimum of 28 days from the time of concrete placement in the absence of strength tests.

No superimposed load, either dead or live, will be allowed upon the bridge during the period the falsework is required to remain in place. If longitudinal construction joints are provided in the roadway of any superstructure, the falsework shall not be released under one portion adjacent to such a joint until the concrete in that portion has attained the required strength and the concrete has been placed in the portion on the opposite side of such joint. The falsework shall not be removed from either side of such joint until all the concrete has attained the required flexural strength and the curing period is completed.

A compressive strength established through field testing to be equivalent to the required flexural strength may be used if approved by the Engineer.

Falsework shall be removed in such a manner as to permit the concrete to take uniformly and gradually the stress due to its weight (mass).

503.06 Forms. Forms shall be set and maintained to the lines and grades shown on the plans.

For continuous concrete slab and cast-in-place concrete girder bridges, forms shall be provided for the full length and width of each continuous unit formed. The Contractor shall submit detailed plans for forms for review and approval by the Engineer.

A weight (mass) of 150 lb/cu ft (2400 kg/cu m) shall be assumed for the concrete in the design of the forms. The design of the forms shall provide for accommodation of incidental loads, settlement, deadload deflection, shrinkage, and deformation of the form components. The forms shall provide the structural capacity required to produce finished concrete to the lines and grades specified on the plans. Forms shall be constructed of wood or metal. Supporting or attaching forms by welding to or drilling or cutting holes in beams will not be allowed.

Wood forms for exposed surfaces shall be made of dressed lumber or plywood. Except for curved and special surfaces, wood forms shall be surfaced on both sides and both edges and shall be sized to uniform thickness.

Metal forms shall be of such thickness that they will remain true to shape. All bolts and rivet heads in contact with concrete shall be countersunk. Clamps, pins, and other connecting devices shall be designed to hold the forms rigidly in place and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or line up properly shall not be used. Metal forms shall be free from rust, grease, or other foreign matter.

Forms shall be filleted at all sharp corners. Triangular moldings used for fillets or V-shaped notches shall have two equal sides. Where the size of the molding is specified, the dimension stated shall be the width of each of the equal sides.

Moldings for fillets and notches shall be 3/4 in. (20 mm). The moldings for corners on handrails and handrail posts shall be 1/2 in. (13 mm). All moldings shall be cut with true edges, surfaced on all sides, and not warped, cracked, or frayed. Forms shall be given a bevel or draft in case of all projections, such as girders and copings.

When directed by the Engineer, temporary openings shall be provided in the bottom of forms for cleaning out all extraneous material immediately prior to placing concrete.

Tie rods, bolts and anchorages within the forms shall be constructed so as to permit their removal to a depth of at least 1 1/2 in. (40 mm) from the face without injury to the concrete. Wire ties, when used, shall be cut back at least 1/2 in. (13 mm) from the face of the concrete upon removal of the forms, except on surfaces not exposed to view, they may be cut flush. All fittings for metal ties shall be of such design that, upon their removal, the cavities which are left will be of the smallest practicable size.

Prior to reinforcement bar placement, forms shall be coated with form oil. When the surfaces are not exposed to view, wood forms may be saturated with water, in lieu of form oil, immediately prior to placement of the concrete.

Forms shall remain in place until permission is obtained from the Engineer for their removal. For Class SI concrete substructure components that will be self-supporting after the forms are removed, and for Class BS concrete components, except those defined in Article 503.16(b), the forms shall remain in place until the concrete has attained the required flexural strength and the curing period is completed. For the remainder of cast-in-place concrete components the forms shall remain in place at least 24 hours.

In the absence of tests to determine the flexural strength, the forms shall remain in place until at least 14 days have elapsed after placing the concrete, exclusive of days the temperature falls below 45 °F (7 °C). When either fly ash or ground granulated blast-furnace slag has been used in the concrete mixture, forms shall remain in place a minimum of 28 days from the time of concrete placement in the absence of strength tests.

A compressive strength established through field testing to be equivalent to the required flexural strength may be used if approved by the Engineer.

The method of form removal shall not result in damage to the concrete. If forms are removed prior to the completion of the required curing period, curing shall be resumed with an approved curing method for the remainder of the curing period.

Additional requirements for form liners and bridge deck forms shall be as follows.

- (a) Form Liners. When form liners are specified, the Contractor shall submit plans for the form liner pattern along with an installation procedure for approval by the Engineer.

All form liner joints and tie holes shall be sealed.

Form release agents shall be according to the recommendations of the form liner manufacturer. The form release agent shall be compatible with all curing agents and admixtures.

The temperature differential between the form liner and concrete shall not be greater than 9 °F (5 °C) for normal ambient conditions. During cold weather, the form liner shall be applied in the same ambient conditions as concrete placement is to take place. In ambient conditions above 90 °F (32 °C), form liner attachment shall allow for thermal expansion.

Variations in dimensions for the cast-in-place concrete with a textured surface shall be within the following tolerances: the width and depth of textured joints shall be within $\pm 1/8$ in. (± 3 mm); the location of the joints shall be within $\pm 1/2$ in. (± 13 mm); and the maximum variation of a joint from a straight line shall be $\pm 1/4$ in. (± 6 mm) in 10 ft (3 m).

A 2 x 2 ft (600 x 600 mm) test sample that includes the proposed textured surface shall be cast and supplied to the Engineer for his/her approval 30 days prior to pouring the cast-in-place concrete.

- (b) Bridge Deck Forms. Forms used in casting concrete bridge decks will not be allowed to remain in place permanently. All tie rods, bolts, anchorages, brackets, and other forming hardware which is incorporated into the bridge deck shall be either epoxy coated or galvanized. Areas of epoxy coating which have been damaged shall be repaired.

When the Contractor uses cantilever forming brackets on the exterior beams or girders, the following procedures will be required.

- (1) Bracket Placement. The resulting force of the leg brace of the cantilever bracket shall bear on the web within 6 in. (150 mm) of the bottom flange of the beam or girder.
- (2) Beam Ties. The exterior beams or girders, supporting cantilever forming brackets, shall be tied together. On stage construction where cantilever brackets are supported on one exterior line of beams or girders, this line shall be tied to the furthest opposite interior line.

The ties shall be spaced at 4 to 8 ft (1.2 to 2.4 m) centers; except, when steel beams or girders are used and the finishing machine rails are located outside of the exterior beam or girder, the tie spacing shall be 4 ft (1.2 m) maximum. Cross frames on steel girders which do not have a top strut shall not be considered a tie.

Ties shall be a minimum of No. 4 (No. 13) epoxy coated reinforcement bars with threaded ends. Each tie bar shall be furnished with a tie bar stabilizing system capable of drawing the tie bar taut. The tie bar stabilizing system shall be approved by the Engineer and shall consist of adjustable tie clips, lag studs, and turnbuckles. The tie clips shall mechanically attach to the outside fascia girder or interior girders as required, and the individual tie bar. The tie bars shall be placed parallel to the transverse reinforcement. The tie bar shall not be placed lower than the bottom transverse reinforcement or higher than the top transverse reinforcement. No welding will be permitted to the structural steel or stud shear connectors, or reinforcement bars for concrete beams, for the installation of the tie bar stabilizing system. After installation, the tie bar shall be drawn taut until the bar does not vary from a straight line from center of tie clip to center of opposite tie clip.

- (3) Beam Blocks. Hardwood 4 x 4 in. (100 x 100 mm) blocks, or material of an equivalent strength, shall be wedged between the webs of exterior and first interior beams within 6 in. (150 mm) of the bottom flanges at each location where the top of the beams are tied together.

If the Contractor elects to use cantilever brackets with an alternate procedure, the Contractor shall submit design calculations and detailed plans for approval by the Engineer.

503.07 Placing and Consolidating. No concrete shall be placed on ice, snow, or frozen foundation material.

The method and manner of placing concrete shall be such as to avoid segregation or separation of the aggregates or the displacement of the reinforcement. The external surface of all concrete shall be thoroughly worked during the operations of placing in such a manner as to work the mortar against the forms to produce a smooth finish free of honeycomb and with a minimum of water and air pockets.

Open troughs and chutes shall extend as nearly as practicable to the point of deposit. Dropping the concrete a distance of more than 5 ft (1.5 m) or depositing a large quantity at any point and running or working it along the forms will not be permitted. The concrete for walls with an average thickness of 12 in. (300 mm) or less shall be placed with tubes so that the drop is not greater than 5 ft (1.5 m).

When concrete is pumped, the equipment shall be suitable in kind and adequate in capacity for the work and arranged so that vibrations will not damage freshly placed concrete. Aluminum pipe or conduit will not be permitted in pumping or placing concrete. Mixed concrete shall be supplied so that the pumping equipment will be in continuous operation.

When placing Class BS concrete with a pump, the discharge end of the pump shall have an "S" shaped flexible or rigid conduit, a 90 degree elbow with a minimum of 10 ft (3 m) of flexible conduit placed parallel to the deck, or a similar configuration approved by the Engineer.

Placing of concrete shall be regulated so that the pressures caused by the wet concrete will not exceed those used in the design of the forms. Special care shall be taken to fill each part of the forms by depositing the concrete as near its final position as possible, to work the coarser aggregates back from the face, and to force the concrete under and around the reinforcement bars without displacing them. Leakage through forms onto beams or girders shall not be allowed to harden and shall be removed while in a plastic state.

The concrete shall be consolidated by internal vibration, except in thin sections or inaccessible locations where consolidation by internal vibration is not practicable.

The Contractor shall provide and use a sufficient number of vibrators to ensure that consolidation can be started immediately after the concrete has been deposited in the forms.

The vibrators shall be inserted into the concrete immediately after it is deposited and shall be moved throughout the mass so as to thoroughly work the concrete around the reinforcement, embedded fixtures, and into the corners and angles of the forms. Vibrators shall not be attached to the forms, reinforcement bars, or the surface of the concrete.

Application of vibrators shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective. The duration of the vibration at the points of insertion shall be sufficient to thoroughly consolidate the concrete into place but shall not be continued so as to cause segregation. When consolidating concrete in bridge decks, the vibrator shall be vertically inserted into the

concrete for 3 - 5 seconds or for a period of time determined by the Engineer. Vibration shall be supplemented by spading when required by the Engineer. In addition to the internal vibration required herein, formed surfaces which will be exposed to view after completion of the work shall be spaded with a spading tool approved by the Engineer.

Concrete shall be placed in continuous horizontal layers. When it is necessary by reason of an emergency to place less than a complete horizontal layer in one operation, such layer shall terminate in a vertical bulkhead. Separate batches shall follow each other closely and in no case shall the interval of time between the placing of successive batches be greater than 20 minutes.

After the concrete has taken its initial set, care shall be exercised to avoid jarring the forms or placing any strain on the ends of projecting reinforcement.

503.08 Depositing Concrete Underwater. Concrete shall not be exposed to the action of water before setting, or deposited in water, except with the approval of the Engineer and under his/her immediate supervision.

When concrete is deposited underwater, it shall be carefully placed in its final position by means of a tremie and shall not be disturbed after being deposited. Still water shall be maintained at the point of deposit and all form work designed to retain concrete underwater shall be watertight. The consistency of the concrete shall be carefully regulated and segregation of the materials shall be prevented. The method of depositing concrete shall produce approximately horizontal surfaces.

The tremie shall consist of a tube having a diameter of not less than 10 in. (250 mm) and constructed in sections having flanged couplings fitted with gaskets. The means of supporting the tremie shall permit the free movement of the discharge end over the entire top surface of the work and shall permit it to be rapidly lowered when necessary to choke off or retard the flow. The discharge end shall be entirely sealed at all times and the tremie tube kept full to the bottom of the hopper. When a batch is dumped into the hopper, the tremie shall be raised slightly to induce the flow of concrete but the lower end shall be kept below the top of the deposited concrete until the batch is discharged. The flow shall then be stopped by lowering the tremie.

At the Contractor's option, pumping equipment may be used in lieu of a tremie to deposit concrete underwater. The Engineer will approve the concrete pumping equipment and its piping before the work is started.

503.09 Construction Joints. Construction joints shall be made only at locations shown on the plans or approved by the Engineer, except in cases of breakdowns or other unforeseen and unavoidable delays.

All construction joints shall be bonded unless noted otherwise. When not shown on the plans, their location shall be confined, as far as possible, to regions of low shearing stress and to locations that will be hidden from view. When possible, the location of construction joints shall be planned in advance and the concrete placed continuously from joint to joint. The reinforcing steel shall extend through such joints. If a construction joint is necessary in the sloped portion of a wingwall or similar location where a featheredge would result, the joint shall be constructed so as to produce an edge thickness of not less than 6 in. (150 mm) in the succeeding layer.

No construction joint shall be placed within 18 in. (450 mm) of the top of any wall or pier unless the details of the work provide for a coping having a thickness of less than 18 in. (450 mm), in which case, at the option of the Engineer, a construction joint may be made at the underside of the coping.

The face edges of all joints which are exposed to view shall be carefully finished true to line and elevation. Shear keys, formed into or out from the surface of the previously placed concrete or steel dowels, shall be used where required. Shear keys formed into the concrete shall be formed by the insertion and subsequent removal of beveled wood strips which shall be thoroughly saturated with water prior to insertion. Steel dowels may, at the discretion of the Engineer, be used in lieu of keys. The size and spacing of the keys and dowels will be as determined by the Engineer.

Between adjacent sections of retaining walls and abutment walls, a V-shaped groove shall be formed in the exposed face of the walls by the use of 1/2 in. (13 mm) triangular molding on each side of the joint.

Care shall be exercised not to injure the concrete or break the concrete-steel bond at any time. In constructing bridge decks where longitudinal joints are specified, a platform shall be constructed outside the longitudinal joints and supported on the lower form, and personnel will not be permitted to stand or walk on the projecting reinforcement bars until the concrete has hardened.

The Contractor, subject to approval of the Engineer, may pour a bridge deck full width with horizontal bonded construction joints between the deck and curbs, parapets, or sidewalks.

- (a) Unbonded Construction Joints. Unbonded construction joints shall be made by forming or striking off the initial concrete placed to a true and even surface and allowing it to set. Loose material shall be removed. The new concrete shall be thoroughly consolidated against the existing concrete.
- (b) Bonded Construction Joints. For bonding to hardened concrete, the existing cement paste shall be removed to create a prepared surface. The surface shall be prepared by washing with water under pressure or by sandblasting to expose clean, well bonded aggregate.

To facilitate the removal of the cement paste, the form in contact with the first pour or the exposed surface of the first pour, may be thoroughly covered with a surface retarder. When the surface retarder is applied directly to the fresh concrete surface, its application shall be completed within 30 minutes after concrete placement.

The surface retarder shall be a ready-to-use liquid compound that delays the set of a concrete surface, and shall be approved by the Engineer in advance of beginning the work. It shall produce results satisfactory to the Engineer and will be evaluated on the tests performed by the Engineer, and on the manufacturer's data recommendations.

The prepared surface of the existing concrete shall be wetted a minimum of one hour before application of the new concrete. The surface shall be

maintained in a dampened condition during that period. Immediately before placing the new concrete, any excess water shall be removed.

503.10 Expansion Joints. Expansion joints shall be constructed to permit freedom of movement. After all other work is completed, all thin shells of mortar and projections of the concrete into and around the joint space that are likely to spall under movement or prevent the proper operation of the joint shall be carefully removed. Expansion joint devices shall be furnished and installed according to Section 520.

- (a) Open Joints. Reinforcement shall not extend across or into an open joint. Open joints in railings or under projecting portions of rail posts shall be formed with square corners unless beveled corners are specified. When not protected by metal expansion guards, open joints in decks and sidewalks shall be finished with an edging tool satisfactory to the Engineer.
- (b) Filled Joints. When preformed joint filler is specified, the material may be any one of the types specified in Section 1051. The preformed joint filler shall be placed in correct position before the adjacent concrete on one side of the joint is poured. The joint filler shall be cut from the least practicable number of pieces to fit exactly and completely fill the space shown on the plans. Loose fitting or open points between sections of filler or between filler and forms will not be permitted.
- (c) Edge Supports. The plates, angles, or other structural shapes provided as edge supports at open joints between adjacent spans shall be furnished and installed according to Article 520.03.

503.11 Drainage Openings. When specified, drain holes shall be constructed in abutment walls, wingwalls, retaining walls, and culvert sidewalls. A cubical deposit of gravel or broken stone shall be placed behind each drain hole according to Article 502.10.

The locations of drains on all concrete superstructures shall be adjusted so as to prevent the discharge of drainage water against any portion of the structure, or directly onto any railroad, highway or unprotected embankment beneath the structure.

Drains consisting only of openings formed in the deck and curbs shall be provided with a surrounding drip notch in the bottom surface of the slab.

Deck drains shall be placed and securely fastened in position before the concrete is placed.

503.12 Nonmetallic Water Seals. Nonmetallic water seals shall be installed as shown on the plans. Provisions shall be made to adequately support the water seal during construction. The projecting edges and ends of partially embedded water seals shall be protected from damage.

When splices are required, they shall be made by heating or vulcanizing to form continuous watertight joints. For the polyvinylchloride water seal, the heat shall be sufficient to melt but not char the plastic.

503.13 Foundations and Footings. When concrete footings are constructed in excavation other than rock, forms shall be used for all vertical surfaces, except when the excavation can be made and will remain true to the required lines and grades until the concrete is placed in the excavated space, the Engineer may permit forms to be omitted. When forms are omitted, the entire excavated space shall be filled with concrete to the elevation of the top of the footing.

When concrete footings are constructed in rock, forms shall be omitted and the entire space shall be filled with concrete up to the top of the footing, or to the top of the rock if the latter is lower.

In all cases, where sumps are required for the disposal of water, they shall be constructed outside the footing areas and forms shall be used for the footings at each sump.

The concrete footing for each substructure unit shall be placed monolithically, except when joints are specified. Vertical construction and expansion joints shown on the plans in abutments and wing walls shall not extend through the footing. In retaining walls or other structures, where joints extend through the footing, the water seal required in the joints between adjacent sections of wall need not extend below the top of the footing.

When concrete encasement is specified, this work shall include the furnishing and placing of the reinforcement required for encasement and any excavation necessary to construct it.

503.14 Seal Coats in Cofferdams. When conditions are encountered which render it impractical to dewater a cofferdam before placing concrete, the Contractor will be permitted to construct a concrete seal coat. Seal coats will not be authorized, except where properly constructed cofferdams cannot be dewatered satisfactorily by ordinary means.

The seal coat shall be constructed below the elevation of the footing and will not be considered a part of the footing. Seal coats shall be designed to withstand the hydrostatic pressure taking into account the resistance afforded by the cofferdam and foundation piles. Seal coats shall be constructed of Class SC concrete. Seal coat concrete shall be placed in one continuous operation according to Article 503.08.

503.15 Surface Finish. Depressions resulting from the removal of ties, and holes left by attachments to rod or bolt anchorages, shall be neatly pointed with a mortar of sand and cement mixed in the proportions of, and color matched to, the concrete being treated.

Air pockets or rough places larger than 1/2 in. (13 mm) diameter shall be pointed as specified in the foregoing paragraph. Honeycombed areas shall be chipped out by the Contractor and inspected by the Engineer before being pointed.

After being pointed, form liners and all other surfaces that will be exposed to view after completion of the work, except those surfaces specified in Articles 503.16(a) and (b)(1), shall be given a normal finish.

- (a) Normal Finish. A normal finish shall consist of the removal of fins, rough spots, stains, hardened mortar or grout, and form lines by rubbing with a No. 16 carborundum stone or an abrasive of equal quality without materially changing the texture of the surface. The rubbing shall be continued sufficiently to produce a surface matching the surrounding surface.

When the surface of concrete shows a film of oil left from an excess of oil on the forms, or the concrete is oil-stained, or is otherwise not of uniform color, the Engineer may require the Contractor to employ the following cleaning method. Mix one part cement and 1 1/2 parts fine sand with sufficient water to produce a grout having the consistency of thick paint. Cement from the source of the cement used in the concrete shall be used in the grout. Wet the surface of the concrete sufficiently to prevent absorption of water from the grout and apply the grout uniformly with brushes, completely filling air bubbles and holes. Immediately after applying the grout, float the surface with a suitable float, scouring the wall vigorously. While the grout is still plastic, the surface shall be finished with a sponge rubber float removing all excess grout. This finishing shall be done at the time when grout will not be pulled from holes or depressions. Next, allow the surface to dry thoroughly, then rub it vigorously with dry burlap to completely remove any dried grout. There shall be no visible film of grout remaining after this rubbing. The entire cleaning operation for any area must be completed the day it is started. No grout shall be left on the wall overnight. No cleaning operations shall be undertaken until all patching and filling of tie holes has been done.

- (b) Rubbed Finish. Surfaces to receive a rubbed finish will be designated on the plans.

The surfaces shall be thoroughly wet with a brush and rubbed with a No. 16 carborundum stone, or an abrasive of equal quality, bringing the surface to a paste. The rubbing shall be continued sufficiently to remove all roughness and projections, producing a smooth dense surface free from pits and irregularities. The material which has been ground to a paste in the above process shall be carefully spread or brushed uniformly over the rubbed surface and permitted to reset. The final finish shall be obtained by a thorough rubbing with a No. 30 carborundum stone, or an abrasive of equal quality, first wetting with a brush as for the initial rubbing. The finish rubbing shall continue until the entire surface is of a smooth texture and uniform in color.

- (c) Bearing Seats. Seats for bridge bearings shall be finished smooth at the proper plane and elevation with a steel trowel within 1/8 in. (3 mm) of the specified elevation before the bearings are placed. After the water sheen has disappeared, the surface shall be given a final finish by brushing with a whitewash brush. The brush shall be drawn across the seat longitudinally with the bridge deck, with adjacent strokes slightly overlapping, producing a uniform, slightly roughened surface with parallel brush marks.

503.16 Concrete Superstructures. The concrete in bridge decks, slab bridges or other monolithic superstructures shall be placed in one continuous operation between expansion or construction joints specified. Sidewalks, curbs, and

medians shall be placed monolithically with the superstructure unless a construction joint is specified.

When falsework is utilized to support steel or precast concrete beams during erection, the falsework shall be removed prior to pouring the deck. The concrete bridge deck or top riding surface of the superstructure shall be constructed so that the top of the finished surface shall be at the final plan elevation after taking into account any anticipated deflection of the supporting members due to the weight of the deck, median, and parapets.

Fogging equipment shall be in operation unless the evaporation rate is less than 0.1 lb/sq ft/hour (0.5 kg/sq m/hour) and the Engineer gives permission to turn off the equipment. The evaporation rate shall be determined according to the figure in the Portland Cement Association's publication "Design and Control of Concrete Mixtures" (refer to the section on plastic shrinkage cracking). The Contractor shall provide temperature, relative humidity, and wind speed measuring equipment. The fogging equipment shall be adjusted to adequately cover the entire width of the pour.

If there is a delay of more than ten minutes during concrete placement, wet burlap shall be used to protect the concrete until operations resume. Concrete placement operations shall be coordinated to limit the distance between the point of concrete placement and concrete covered with cotton mats for curing. The distance shall not exceed 35 ft (10.7 m). For pour widths greater than 50 ft (15 m), the distance shall not exceed 25 ft (7.6 m).

(a) Riding Surfaces of Superstructures. Superstructure riding surfaces shall be finished and textured as follows.

- (1) Initial Finishing. After the concrete is placed and consolidated, it shall be struck off and finished with a power driven finishing machine.

The finishing machine will not be required for that portion of the surface outside of the outer construction joints shown on the plans when the distance from the construction joint to the parapet flow line is less than 6 ft (2 m). The concrete surface in these areas shall be finished with a hand operated float.

At the Contractor's option, a vibrating screed may be used in lieu of a finishing machine for superstructures with a pour width less than 16 ft (5 m). After the concrete is placed and consolidated, it shall be struck off with a vibrating screed allowing for camber, if required. The vibrating screed shall be of a type approved by the Engineer. A slight excess of concrete shall be kept in front of the cutting edge at all times during the striking off operation. After screeding, the entire surface shall be finished with long handled floats.

Long handled floats having blades not less than 3 ft (1 m) in length and 6 in. (150 mm) in width may be used to smooth and fill occasional porous or open-textured areas in the concrete surface, but shall not be used to float the entire surface. The Contractor shall take immediate corrective action to eliminate the causes of the porous or open-textured areas as they occur.

The Contractor may, at their option, transversely float the entire surface with a hand-operated float having blades not less than 10 ft (3 m) in length and 6 in. (150 mm) in width. If the Contractor chooses to transversely float the entire surface with the 10 ft (3 m) hand float and surface corrections are made, straightedge testing while finishing will not be required.

Water will not be permitted to be applied to the bridge deck surface unless it can be demonstrated to the Engineer that workability cannot be obtained. If water is permitted by the Engineer, it shall be applied in a fine mist by means of a sprayer, at a distance not to exceed 12 in. (300 mm) from the surface. Application by brushes or any other method that concentrates water will not be permitted.

Excess concrete, mortar, or paste produced by the finishing process shall not be discarded into areas of the bridge deck that will be covered by sidewalks, medians, curbs, or parapets or otherwise incorporated into the work but shall be removed and disposed of properly.

- (2) Straightedge Testing and Surface Correction. After the finishing has been completed and while the concrete is still plastic, the surface shall be tested for trueness with a 10 ft (3 m) straightedge. The Contractor shall furnish and use an accurate 10 ft (3 m) straightedge which has a handle not less than 3 ft (1 m) longer than 1/2 the pour width. The straightedge shall be held in contact with the surface and passed gradually from one side of the superstructure to the other. Advance along the surface shall be in successive stages of not more than 1/2 the length of the straightedge. Any depressions found shall be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished. High areas shall be cut down and refinished. The straightedge may be used to finish and seal the bridge deck surface when approved by the Engineer.
- (3) Texture. All riding surfaces shall be textured in the plastic state and subsequently saw cut grooved after the concrete has cured.
 - a. Plastic Texture. The texture shall be formed into the plastic concrete with a burlap or artificial turf carpet drag. The burlap or artificial turf shall be attached to a work bridge riding on rails, or other approved device that will permit control of the time and rate of texturing. The burlap or artificial turf carpet shall have a length equal to the width of the pour or from face-to-face of curbs, as applicable. The burlap or carpet shall be laid on the concrete surface and dragged, parallel to the centerline of the roadway, in the direction that the superstructure is being poured with approximately 2 ft (600 mm) of its width in contact with the concrete surface. The drag shall be operated so as to produce a uniform finish. The burlap shall be double thickness and shall be kept saturated with water while in use. The artificial turf carpet may be weighted, if necessary, for maintaining intimate contact with the concrete surface.

- b. Saw Cut Grooving. The grooving operation shall not be started until after the expiration of the required curing or protection period and after correcting excessive variations by grinding or cutting has been completed.

The grooves shall be cut into the hardened concrete, perpendicular to the centerline, using a mechanical saw device equipped with diamond blades that will leave grooves 1/8 in. wide and 3/16 in. \pm 1/16 in. deep (3 mm wide and 5 mm \pm 1.5 mm deep). The Contractor shall have the option of constructing the grooves at either a random spacing of 5/8 to 1 1/4 in. (15 to 30 mm) centers with an average spacing of 7/8 in. (22 mm) or a uniform spacing of 3/4 in. (20 mm) centers. The grooving shall be stopped 1 ft (300 mm) from the faces of curbs or parapets and 2 in. \pm 1 in. (50 mm \pm 25 mm) from deck drains and expansion joints. If grooving must be performed as part of stage construction, the grooving may be deferred until at least two adjacent lanes have been poured.

The removal of slurry shall be continuous throughout the grooving operations. The grooving equipment shall be equipped with vacuum slurry pickup equipment which shall continuously pick up water and sawing dust, and pump the slurry to a collection tank. The slurry shall be disposed of off site according to Article 202.03.

Cleanup shall be continuous throughout the grooving operation. All grooved areas of the deck shall be flushed with water as soon as possible to remove any slurry material not collected by the vacuum pickup. Flushing shall be continued until all surfaces are clean.

- (4) Surface Smoothness. All riding surfaces shall be tested for trueness at the expiration of the required curing or protection period. The entire surface shall be tested by means of a 16 ft (5 m) straightedge placed parallel to the grade line and touching the surface. Variations measured from the face of the straightedge to the surface of the superstructure shall not exceed 3/16 in. (5 mm). Variations greater than 3/16 in. (5 mm) shall be removed by grinding or cutting. Bushhammering or any method involving impact shall not be used.
- (b) Concrete Superstructures Other Than Decks. Concrete parapets and railings, and those concrete curbs, sidewalks, and medians not placed monolithically with the deck shall be placed after the deck concrete has attained the required strength and the deck curing period is complete.
- (1) Curbs, Sidewalks, and Medians. Forms for concrete sidewalks, curbs, and medians shall be adjusted to correct elevation, camber, and alignment after the deck or superstructure has been placed. After the concreting has been completed, they shall be struck off and finished with floats and trowels.

The edge of curbs, or walks not more than 2 ft (600 mm) in width, shall be either beveled by the use of 3/4 in. (20 mm) triangular molding at the top of the face forms or edged with an edging tool. The edge of walks over 2 ft (600 mm) in width shall be finished with an edging tool. Transverse construction joints shall not be edged and transverse grooves shall not be provided.

The top surface of sidewalks shall be finished according to Article 424.06, except the surface shall not be divided by grooves.

- (2) Parapets and Railings. Forms for concrete parapets and railings shall be held rigidly to line and grade and removed without injury to the concrete. Special care shall be exercised to secure smooth, tight fitting forms. All moldings, panel work, and bevel strips shall be straight and true with neatly mitered joints and all corners in the finished work shall be true, sharp, and clean cut. Alignment of forms and grade of top chamfer strips shall be checked immediately after the placing of concrete in the forms. Rail posts, openings, and panels shall be constructed with vertical lines, regardless of the grade on which the railing is constructed.

503.17 Curing. Concrete shall be cured according to Article 1020.13.

503.18 Waterproofing. The surfaces of concrete structures designated on the plans shall be waterproofed as follows.

- (a) Surfaces Below Ground. Surfaces below the ground which are to be waterproofed shall be given either one coat of asphalt primer and two mop coats of petroleum asphalt Type I; or two mop coats of asphalt emulsion.
- (b) Surfaces Above Ground. Surfaces above the ground line which are to be waterproofed shall be given one coat of asphalt primer and two mop coats of petroleum asphalt Type II.

With the approval of the Engineer, spraying will be permitted in lieu of mopping.

The surfaces to be waterproofed shall be smooth and free from projections or porous places. The surfaces shall be cleaned of dust, dirt, grease, and loose particles and shall be dry at the time the waterproofing is applied. Petroleum asphalt shall not be applied until at least seven days have elapsed after placing of the concrete. Asphalt emulsion may be applied as soon as the forms are removed. No waterproofing shall be done in wet weather, or if local conditions indicate that rain is imminent, or when the temperature of the air in the shade is below 50 °F (10 °C), without the written permission of the Engineer, except as specified for asphalt emulsion below.

When waterproofing with petroleum asphalt, the primer shall be applied to the surface of the concrete in a uniform coating and may be applied without heating. The primer shall be applied at least 24 hours before applying the first mopping of hot asphalt. The two mop coats shall be heated to a temperature which will permit uniform application. Asphalt shall not be heated above 350 °F (175 °C). The amount applied in the two moppings shall be approximately 8 gal/100 sq ft (3 L/sq m) of

finished work. If any imperfections appear in the waterproofing, additional coats will be required.

When waterproofing with asphalt emulsion, two uniform coats, free from holes or holidays, shall be applied. The second coat shall be applied as soon as the first coat has dried. The minimum total quantity applied in the two coats shall be 3 gal/100 sq ft (1 L/sq m). When the temperature of air in the shade is below 45 °F (7 °C), and the requirements of Article 1020.13(d) have been complied with, asphalt emulsion waterproofing may be applied down to a temperature of 32 °F (0 °C). Regardless of the temperature during application the material shall be kept at a temperature above 50 °F (10 °C). A minimum drying time of 24 hours is required before backfilling, but no backfilling shall commence until the requirements of Article 502.10 are met.

503.19 Protective Coat Application. A protective coat shall be applied to the entire top surface of bridge decks, hubguards, and the top and inside vertical faces of sidewalk, parapets, end posts, and wings when the concrete is at least 14 days old. This work shall be performed after saw cut grooving, and before the bridge deck is marked and opened to traffic.

Before the protective coat is applied, the concrete surface shall have at least a 48-hour drying period since the last rain and shall be cleaned to remove all oil, grime, and loose particles which would prevent the mixture from penetrating the concrete. Immediately prior to application of the protective coat, the surface shall be blown with oil-free compressed air.

The protective coat shall consist of two applications of the mixture and each application shall be at a rate of 50 sq yd/gal (11 sq m/L) or less.

The protective coat shall be sprayed on the surface using hand methods or with a mechanical spraying machine which will perform the work in a satisfactory manner. The spray nozzle(s) shall be within 18 in. (450 mm) of the concrete or as directed by the Engineer. The interior of the distributor tank shall be thoroughly cleaned prior to placing the protective coat therein. Unless otherwise directed by the Engineer, the temperature of the concrete and air shall be 40 °F (4 °C) or higher at the time of application.

The second application of the protective coat shall be made when, in the opinion of the Engineer, the concrete has regained its dry appearance.

Traffic shall be prohibited from the area until the concrete has regained its dry appearance.

If an application of sand is required by the Engineer for blotter material, it will be paid for according to Article 109.04.

503.20 Opening Structures to Traffic. Concrete structures shall be opened to traffic according to Articles 503.05, 503.06, and 1020.13.

503.21 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. This work will be measured for payment in place and the volume computed in cubic yards (cubic meters). The dimensions used will not exceed those shown on the plans or ordered in writing by the Engineer. Increased quantities from the omission of forms for footings will not be measured for payment. Deductions will be made for the volume of piling, except for steel H pile, encased in the concrete. No deduction will be made for the volume of concrete displaced by steel reinforcement, drain holes, floor drains, and expansion joint material. The reduction in quantity of concrete involved in scoring and chamfers 2 sq in. (1300 sq mm) or less in cross sectional areas will be neglected in all measurements for payment.

When shown on the plans or ordered in writing by the Engineer, concrete for seal coats will be measured for payment within the cofferdam sheeting. The vertical dimension used in computing the volume will be the average thickness of the seal between the top of the seal not to exceed the elevation shown on the plans for the bottom of the footing and the bottom of the excavation, but in no case lower than the elevation shown on the plans for the bottom of the seal coat. The horizontal dimensions used will be the average measurement from center to center of the interlocks of the sheet piling in opposite walls of the cofferdam, but in no case will these dimensions be taken as more than 2 ft (600 mm) beyond the neat lines of the footing in any direction, except that provision may be made for a sump at one end of the cofferdam if necessary.

Reinforcement bars will be measured for payment according to Article 508.07.

Bridge deck grooving will be measured for payment in place and the area computed in square yards (square meters). No deductions will be made for grooving omissions at deck drains, expansion joints, longitudinal joints, or lane lines.

Protective coat will be measured for payment in place and the area computed in square yards (square meters).

Form liner textured surfaces will be measured for payment in place and the area computed in square feet (square meters).

Joint fillers, water seals, drain holes, floor drains and welded wire fabric reinforcement, except when specified, will not be measured for payment.

Rubbed finish will be measured for payment in place and the area computed in square feet (square meters).

503.22 Basis of Payment. This work will be paid for at the contract unit price per cubic yard (cubic meter) for CONCRETE STRUCTURES and CONCRETE SUPERSTRUCTURE.

Other cast-in-place concrete for structures will be paid for at the contract unit price per cubic yard (cubic meter) for CONCRETE HANDRAIL, CLASS MS CONCRETE, CONCRETE ENCASEMENT, and SEAL COAT CONCRETE.

Reinforcement bars will be paid for according to Article 508.08.

Expansion bolts, when specified, will be paid for according to Article 540.08.

Rubbed finish will be paid for at the contract unit price per square foot (square meter) for RUBBED FINISH.

Form liner textured surfaces will be paid for at the contract unit price per square feet (square meter) for FORM LINER TEXTURED SURFACE.

Floor drains, other than frames and grates, will be paid for at the contract unit price per each for FLOOR DRAINS.

Texturing of bridge decks by saw cut grooving will be paid for at the contract unit price per square yard (square meter) for BRIDGE DECK GROOVING.

Protective coat will be paid for at the contract unit price per square yard (square meter) for PROTECTIVE COAT.

Concrete protected according to Article 1020.13(d) may be paid for at the adjusted unit prices which will be the following percentages of the contract unit price for the classes of concrete involved. These adjustments will be made only when they are authorized in writing by the Engineer. No adjustment will be made in the contract unit prices for any concrete if winter work is necessary to meet the required completion dates specified in the contract.

UNIT PRICE ADJUSTMENTS	
Type of Construction	Percent Adjustment in Unit Price
For concrete in substructures, culverts (having a waterway opening of more than 10 sq ft (1 sq m)), pump houses, and retaining walls (except concrete pilings, footings, and seal coats):	
When protected by:	
Protection Method II	115 %
Protection Method I	110 %
For concrete in superstructures:	
When protected by:	
Protection Method II	123 %
Protection Method I	115 %
For concrete in footings:	
When protected by Method I, II or III	107 %
For concrete in slope walls:	
When protected by Method I	107 %

SECTION 504. PRECAST CONCRETE STRUCTURES

504.01 Description. This work shall consist of the construction of structures or portions thereof, with precast concrete or precast, prestressed concrete structural members.

504.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Reinforcement Bars	1006.10
(c) Prestressing Steel	1006.10
(d) Welded Wire Fabric	1006.10
(e) Transverse Tie Rods and Dowel Rods	1006.06
(f) Nonshrink Grout	1024.02
(g) Epoxy Bonding Compound	1025.01
(h) Precast Concrete Products	1042
(i) Preformed Bearing Pads	1082

504.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Hand Vibrator	1103.17(a)
(b) Vibrating Screed	1103.17(g)

CONSTRUCTION REQUIREMENTS

504.04 General. This work shall be according to Section 503, and the following.

504.05 Precast Concrete Members. Tie bolts, anchor dowels, bearing pads, inserts, nonshrink grout, and other items required for the erection of the units shall be furnished with the member.

Erection of precast bridge slabs shall commence at the centerline and proceed, one slab at a time, working out to the curb. As each slab is placed, the transverse tie bars shall be inserted and secured. Any shifting of the beams must be done while they are held free of the supports by the hoisting device or crane. The use of a steel pinch bar will not be permitted.

The abutting edges of each unit shall be carefully cleaned of any concrete or extraneous matter in order that the slabs can be bolted tightly together.

Care shall be exercised to keep the bearing seat areas free of foreign material when placing the slabs. After the units have been placed and fastened together and the end anchor dowels are placed, the longitudinal keyways between the units shall be filled with nonshrink grout according to Article 504.06(e).

Pile caps shall be carefully lowered into their proper position over the piles and to the specified elevation. After the units have been placed, the recess holes shall be filled with nonshrink grout according to Article 504.06(e).

504.06 Precast, Prestressed Concrete Members. Deck beams, I-beams, Bulb T-beams, and other prestressed concrete structural members shall be fabricated according to the Department's "Manual for Fabrication of Precast Prestressed Concrete Products" in effect on the date of invitation for bids.

- (a) **Damage Inspection.** The completed members shall not be placed until they are inspected for damage at the jobsite by the Engineer. The members shall be inspected for damage again after placing and before decking begins.
- (b) **Deck Beam Erection Tolerances.** The tolerance for the total width of the deck shall be the theoretical width plus 1/2 in. (13 mm) per joint. The maximum distance between beams, measured below the keyway, shall be 3/4 in. (20 mm). The deviation from the specified width for the transverse joints shall be - 1/4 in. (6 mm) to + 1/2 in. (13 mm) at expansion joints, and 0 to + 1/2 in. (13 mm) at fixed joints.

The beams individually may comply with the dimensional tolerances and still not place satisfactorily in the structure. Acceptance of the beams, therefore, will be conditioned upon satisfactory placement.

- (c) **Handling, Storing, and Transporting.** The members shall be maintained in upright position at all times and shall be supported as described herein. During lifting, members shall be supported only by the inserts provided for that purpose. During transportation, wood blocks or other suitable material shall be placed under the tie down chains to prevent chipping of the concrete. If temporary storage is required at the jobsite the members shall be supported on timber, at least 4 in. (100 mm) wide, and shall be maintained in level position so that no twisting of the member will occur. For both transportation and temporary storage, the ends of I-beams shall not extend a distance of more than the depth of the beam and, in no case, more than 3.5 ft (1.1 m) beyond the bolsters or other supports. The ends of Bulb T-beams shall not extend more than 6 ft (1.8 m) beyond the supports. The ends of deck beams shall not extend a distance of more than 1 1/2 times their depth, and in no case more than 3 ft (0.9 m), beyond the supports. No stacking of deck beams will be allowed at the jobsite.
- (d) **Erection.** Beams shall be placed on clean bridge seats and tops of bearing devices. Any shifting of beams shall be done while they are held free of the supports.

Precast members shall be handled with a suitable hoisting device or crane provided with a spreader sling of sufficient capacity to handle the members. The spreader shall be of sufficient length to prevent horizontal forces in the member due to lifting, and shall be equipped with leads and hooks at each end. For the purpose of engaging the threaded inserts provided in the member, the manufacturer shall provide a sufficient number of eye bolts of proper size.

Before lifting the member, all lifting inserts in each end shall be fully engaged with the spreader lead hooks. In the event that raising by alternate lifting and blocking of opposite ends is performed, the lifted end shall not be rotated unless a proper pivoting device for the opposite end has been provided.

Erection of deck beams shall begin at the expansion end. During the initial placement of the beams, every effort shall be made by the Contractor to achieve optimum match between beams. The Contractor may be required to shift or interchange interior beams, or pairs of beams on skewed bridges, to achieve a better fit when directed by the Engineer. As the beams are placed in their final position, and prior to securing transverse ties and drilling and grouting dowels, the beams shall be brought to firm even bearing on the seats through the use of the bearing pads and fabric shims furnished with the beams, and/or grinding of the concrete seats as required.

After deck beams are properly placed and firm even bearing assured, the beams, either in pairs for skewed structures or all beams for right angle structures, shall be secured in lateral position by placing and tightening of the transverse tie assemblies. Dowels at the fixed ends of the deck beams shall be installed and nonshrink grout placed. In addition, the cast-in-place concrete at the expansion end of the deck beams shall be placed and cured.

In stage construction with deck beams, the first stage shall be constructed as a complete deck including grouting according to Article 504.06(e) and the placement of the wearing surface if one is specified. The transverse ties for the first stage of construction shall not be released during construction of the next stage. Threaded sleeves shall be used to secure the deck beams to the previous stage and at no time shall the transverse tie nuts for the previous stage be loosened or removed.

The next stage of construction shall proceed as specified above, except the keyway along the stage construction line shall be aligned with clamping devices. This keyway shall be the last keyway to be grouted.

The Contractor shall furnish all material for the clamping devices, including sufficient 1/16 in. (2 mm) and 1/8 in. (3 mm) steel shims to adjust for differential elevations between the two deck beams.

The 2 in. (50 mm) holes for the clamping devices shall be cast at the locations shown on the plans. Care shall be taken to drill the holes perpendicular to the beams. The clamping devices shall be installed and pulled up tight so that a full, firm bearing is obtained between the clamping plates and the deck beam concrete.

- (e) Grouting. After the erection is completed, the longitudinal keyways between beams shall be filled with nonshrink grout. The Contractor shall also place nonshrink grout between the ends of the deck beams at fixed piers and for the transverse tie assembly pockets. During the curing period, no vehicular traffic, including the Contractor's equipment, will be permitted on the beams. Grouting of the keyway at the staged construction line shall be done after the shear key clamping devices are fully secured. The clamping devices

shall not be loosened or removed until the nonshrink grout has fully cured. After the clamping devices are removed the drilled holes and unfilled area of adjacent key shall be flushed out with water and then completely filled with grout.

The temperature of the grout at time of placement shall be a minimum of 50 °F (10 °C) and a maximum of 90 °F (32 °C).

Surfaces to which the grout is applied shall be wetted a minimum of one hour before placement of grout. The surface shall be maintained in a dampened condition during that period. Prior to placement of grout, all excess water shall be removed and all openings between beam edges at the base of the longitudinal keyways shall be caulked or sealed with a suitable compressible material to prevent leakage. Keyways shall be clean and free of all oil, grease, laitance and other foreign substances.

During placement, the grout shall be worked into the area with a trowel blade or a pencil vibrator. The surface shall be troweled to a smooth finish. The nonshrink grout shall be cured with burlap or cotton mats according to Article 1020.13 for a minimum of three days. Curing shall commence as soon as practicable after finishing.

The nonshrink grout for the longitudinal keyways and between the ends of deck beams at fixed piers will be inspected by the Engineer for cracks. When deck beams are used as the final driving surface, any cracks 0.007 in. (0.2 mm) or wider shall be sealed according to Section 590.

If cracks propagate along the keyway from the ends of beams, it could indicate one or more beams are not firmly seated. Prior to sealing, the Contractor shall check for beam wobble and shim any beams not firmly seated.

504.07 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Precast concrete bridge slabs and precast, prestressed concrete deck beams will be measured by the square foot (square meter) of horizontal surface area of the individual slabs or beams, as shown on the plans. In determining the total number of square feet (square meters) to be paid for, the overall horizontal surface area of all the slabs or beams specified will be used.

Precast, prestressed concrete I-beams, or Bulb T-beams will be measured by the foot (meter). In determining the total length of beams to be paid for, the specified overall length of the individual beams will be used.

Precast concrete pile caps will be measured for payment in place as each precast concrete cap.

504.08 Basis of Payment. This work will be paid for at the contract unit price per square foot (square meter) for PRECAST CONCRETE BRIDGE SLAB and PRECAST, PRESTRESSED CONCRETE DECK BEAMS, of the depth specified, or per foot (meter) for FURNISHING AND ERECTING PRECAST PRESTRESSED CONCRETE I-BEAMS, of the depth specified, or FURNISHING AND ERECTING PRECAST PRESTRESSED CONCRETE BULB T-BEAMS, of the depth specified.

Precast concrete pile caps will be paid for at the contract unit price per each for PRECAST CONCRETE CAPS.

SECTION 505. STEEL STRUCTURES

505.01 Description. This work shall consist of furnishing, erecting, and painting steel structures or portions thereof.

505.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Structural Steel	1006.04
(b) Turned and Ribbed Bolts	1006.07
(c) High-Strength Steel Bolts, Nuts and Washers	1006.08(a)
(d) Anchor Bolts and Rods	1006.09
(e) Steel Forgings	1006.12
(f) Gray Iron Castings	1006.14
(g) Malleable Castings	1006.16
(h) Paint Materials and Mixed Paints	1008.01, 1008.02
(i) Stud Shear Connectors	1006.32

Materials for structures that will carry railroad traffic shall satisfy AREMA Specifications.

505.03 Drawings. Before steel fabrication begins, the Contractor shall submit duplicate prints of shop drawings to the Engineer for review and preliminary approval. These drawings shall be on 11 x 17 in. (275 x 425 mm) sheets. Each sheet shall provide adequate space for review and approval stamps at the lower right corner, and both lettering and details must insure legibility for review and reproduction after microfilming. Each drawing shall be completely titled according to the contract plans, including structure number, state contract number, route, section, and county, and shall pertain to only one structure. If the submitted shop drawings have significant discrepancies, revised sets must be submitted until details comply with the contract requirements. After all review comments have been addressed and preliminary approval is given, the Contractor shall furnish six or more prints of the drawings as directed by the Engineer, and these shall be distributed and become a part of the contract. Changes to previously approved shop drawings shall be subject to the approval of the Engineer, and the Engineer shall be supplied with a record of all such changes.

After the Engineer's preliminary approval and prior to distribution, prints of shop drawings for structures that will carry railroad traffic shall also be submitted for the approval of the Railroad Engineer. Upon request, the Contractor shall also furnish full size reproduces, 22 x 34 in. (550 x 850 mm), including margins. The margin at the

left end shall be 1 1/2 in. (40 mm) and the others 1/2 in. (13 mm) wide. These reproducibles shall become the property of, and shall be delivered to, the Railroad upon completion of the contract.

During the preparation of shop drawings, the Contractor shall check all general dimensions of the steel work and shall report any discrepancies discovered to the Engineer for revision and correction before fabrication is begun. Allowance will be made to the Contractor for additional material fabricated to correct reported contract plan errors.

505.04 Fabrication. Structural steel shall be fabricated and stored according to the following requirements, except for structures carrying railroad traffic. The AREMA Specifications shall govern fabrication of structures carrying railroad traffic, except the requirements of this section shall govern when they are more demanding. Fabrication shall be performed by structural steel fabricators meeting the certification requirements of Article 106.08.

- (a) **Workmanship and Finish.** The workmanship and finish shall satisfy applicable Specification and Code requirements.
- (b) **Storage of Materials.** Structural material, either plain or fabricated, shall be stored above the ground upon platforms, skids, or other supports. It shall be kept free from dirt, grease, or other foreign matter, and shall be protected as far as practicable from corrosion.
- (c) **Straightening or Curving Material.** Straightening shall be done by methods which will not injure the metal. Sharp kinks and bends may be cause for rejection of the material. Heat straightening of AASHTO M 270 Grade 100 and 100W material shall be done only when approved by the Engineer and then only under rigidly controlled procedures.

The Contractor may fabricate curved welded girders by cutting the flanges to the required curvature prior to welding the web. Curved welded girders or rolled beams may be fabricated as a straight unit, and through the application of heat to induce the required curvature. Heat-curving will not be permitted on beams or girders fabricated of AASHTO M 270 Grade HPS 485W (HPS 70W) or 690 & 690W (100 and 100W) steels. Cold bending of beams or girders to the required curvature will be permitted provided the proposed detailed procedures receive the Engineer's approval and the finished member approximates a smooth curve without kinks or twist. When beams or girders are to be heat curved, the Contractor shall satisfy the following requirements.

- (1) **Type of Heating.** Beams or girders may be curved by either continuous or V-type heating. For both types of heating, the flange areas to be heated are those that will be on the inside of the horizontal curve after cooling. Heating both inside and outside flange surfaces is mandatory when the flange thickness is 1 1/4 in. (30 mm) or greater, and the two surfaces shall be heated concurrently. The heating shall progress along the top and bottom flange at approximately the same rate. Heating shall be performed using multi-orifice (rosebud) heating torches manipulated to avoid overheating. Torches shall use air-propane or air-

natural gas unless other methods are approved by the Engineer for the specific girder configuration.

For the continuous method, strips centered approximately 2 in. (50 mm) inside the edge of the top and bottom flanges shall be heated simultaneously. The strips shall be of sufficient width and temperature to obtain the required curvature.

For the V-type heating, the top and bottom flanges shall be heated in truncated triangular areas spaced at regular intervals along each flange. The heat patterns applied to the inside flange surface shall terminate just before reaching the juncture of the web and the flange. For curvature radii greater than 1000 ft (300 m), heating patterns on the outside flange surfaces shall have their apex coincide with the plane of the web centerline, and for smaller radii, the outside patterns shall extend past the web centerline a distance of 1/8 of the flange width or 3 in. (75 mm), whichever is less.

Beginning at the truncated end of each heating pattern, heating shall progress toward the base of the pattern, spreading with an included angle of 15 to 30 degrees. The base of the pattern shall not exceed 10 in. (250 mm) regardless of flange width and thickness. The heating torch progresses toward the base of the heating pattern after the truncated end of the truncated pattern reaches the specified temperature. Once heating begins to progress towards the base at the pattern, the heating torch(es) shall not be returned to the apex of the heating triangle. Heat pattern spacing and size shall be as required to obtain the required curvature.

The maximum temperature shall be prescribed below. If chording or twisting occurs in the member that is unsatisfactory to the Engineer, the Contractor shall correct the situation using Engineer-approved methods to obtain acceptable results.

- (2) Temperature Control. Heat curving shall be conducted so that the internal temperature of the steel does not exceed 1150 °F (620 °C). "Internal steel temperature" shall be represented by the surface temperature approximately five seconds after passage of the torch. Heating shall be confined to the planned patterns or areas, and shall bring the steel within the pattern to the desired temperature as rapidly as possible without overheating. The temperature range shall be documented, based on frequent monitoring with appropriate temperature indicating crayons or other calibrated equipment during the heating and cooling of the member. Any procedure which causes the internal steel temperature to exceed 1150 °F (620 °C) will be considered destructive heating and be cause for rejection of the member. Steel rejected for overheating may be investigated for reacceptance or repair by tests acceptable to the Engineer. The costs of such tests shall be borne by the Contractor.

After completing a planned set of heat patterns along the member's length, additional heat shall not be applied until the entire member has

cooled below 160 °F (70 °C) and the net displacement has been verified. Accelerated cooling with water or water mist will not be permitted. Cooling with dry compressed air will be permitted after the steel has cooled to 600 °F (315 °C).

- (3) Position for Heating. Members may be heat-curved with the web either vertical or horizontal. When curved in the web-vertical position, the member shall be braced or supported so that the lateral deflection will not cause instability. When curved in the web horizontal position, the member shall be supported near its ends and have limiting blocks at intermediate points as to obtain the desired curvature. Restraints or preloads may be used to facilitate heat-induced steel movements, but additional external loads shall not be applied to heated steel. Preloads, including the member's self-weight, shall not cause stresses exceeding 50 percent of the material's nominal yield at ambient temperature.
- (4) Sequence of Operations. Members shall be heat-curved before they are painted. The heat curving may be conducted either before or after transverse intermediate stiffeners are installed. Unless provisions are made for girder shrinkage, connection and bearing plates shall be located and attached after heat-curving. If longitudinal stiffeners or cover plates are required, they shall be curved separately and then welded to the previously curved girder.

Girders shall be fabricated to specified cambers by cutting web plates to the required geometries before attaching flanges. Heating may be used for small camber corrections if the method and points of application are approved by the Engineer. The prescribed camber shall be obtained before heat-curving and the Contractor shall make allowance for any anticipated losses during fabrication. Rolled shapes shall not be shop cambered, unless otherwise specified. If the contract requires cambering rolled shapes or if straightening as received material is necessary, proposed procedures must be submitted for the Engineer's approval.

Horizontal curvature and vertical camber will not be measured for final acceptance until all heating and welding operations are completed and the flanges have cooled to a uniform temperature. Horizontal curvature will be checked with the beam or girder in upright position. For beams or girders curved after reaming or drilling field splices, at least 20 percent of the girder or beam lines shall be check assembled after curving to verify final geometry. If problems are discovered, additional lines shall be checked until the Engineer is satisfied that the problems have been corrected.

- (d) Fastener Holes. All fastener holes shall be either punched or drilled. In all cases hereafter, drilling may be substituted for punching of full-size holes; subdrilling may be substituted for subpunching; and holes may be drilled in assembly ("from the solid") instead of being subpunched or subdrilled and reamed. Drilling in assembly shall be done with the material in the same configuration required for reaming. Holes punched or drilled full-size shall be 1/16 in. (2 mm) larger than the nominal diameter of the fasteners.

Subpunched holes for fastener diameters greater than 5/8 in. (16 mm) shall be 3/16 in. (5 mm) smaller than the nominal diameter of the fasteners and for smaller fasteners, the holes shall be subpunched to the fastener's nominal diameter. Subpunched or subdrilled holes shall be reamed to 1/16 in. (2 mm) larger than the nominal diameter of the fasteners.

Holes in carbon steel thicker than 3/4 in. (20 mm) or alloy steel thicker than 5/8 in. (16 mm) shall be drilled or subdrilled and reamed. Punching or subpunching shall not be permitted.

Where reaming is not required, holes in carbon steel up to 3/4 in. (20 mm) thick or in alloy steel up to 5/8 in. (16 mm) thick may be punched to their final specified size.

Holes for field connections of beams, girders, main truss or arch connections, skewed portals, and rigid frames carrying design loads shall be subpunched and reamed with the members assembled in the shop and supported against deadload deflection.

The accuracy of the assembly, including camber, alignment of subpunched holes, and finished-to-bear joints shall be approved by the Engineer before reaming is commenced.

Holes may be punched or drilled to their final specified size for field connections of secondary items including: lateral bracing for girders, truss cords, and arch ribs; hanger supports for laterals and utilities; portal and sway bracing; and cross frames or diaphragms that do not require reamed holes. All holes for end field connections of floor beams shall be subpunched or subdrilled and then reamed to a template, and all corresponding holes in the members to which they connect shall be reamed to the same template, or these connections may be reamed with the members assembled. Stringer connections to floor beams may have holes punched or drilled to their final specified size. Reaming templates shall have hardened steel bushings and reference lines inscribed to locate the template on the members.

Computer-numerically-controlled (CNC) equipment may be used to produce full-sized holes in components otherwise requiring reamed, sub-sized holes, subject to the Engineer's approval and the demonstrated accuracy of the CNC system. Accuracy must be verified by periodic check assemblies of components, and the Contractor's quality control plan for the system must be acceptable to the Engineer. Errors detected by check assemblies will require additional assemblies to define the extent of problems and subsequent CNC work may be restricted or prohibited until system corrections are accepted by the Engineer.

- (1) Punched Holes. The diameter of the die shall not exceed the diameter of the punch by more than 1/16 in. (2 mm). Holes shall be cleanly cut, without torn or ragged edges.
- (2) Accuracy of Unreamed Holes. All subdrilled or subpunched holes shall be so accurate that after steel is assembled and before reaming, a

cylindrical pin 1/8 in. (3 mm) smaller in diameter than the punched hole may be inserted perpendicular to the face of the member, without drifting, through at least 75 percent of the holes in the connection or the pieces will be rejected. Holes punched or drilled to their final specified size without assembly shall be so accurate that fasteners may be installed without reaming or additional drilling.

- (3) Reamed or Drilled Holes. Reaming and drilling shall be perpendicular to the faying (contact) surface of the connection. Drilling shall be done with twist drills and reaming with fluted or adjustable reamers. Where practical, reaming shall be directed by mechanical means, and done after all the components are assembled and firmly secured. Unless otherwise approved by the Engineer, assembled parts shall be taken apart for removal of cutting oil, shavings, and burrs caused by drilling and reaming.
 - (4) Accuracy of Reamed and Drilled Holes. Where full-size holes are reamed, drilled from the solid, or made by CNC equipment, 85 percent of the holes in any group shall show no offset greater than 1/32 in. (1 mm) between adjacent thickness of metal.
 - (5) The Contractor shall be responsible for the accuracy of all holes, regardless of tolerance in dimensions of rolled sections or fabricated members. If the required accuracy cannot be obtained otherwise, holes shall be drilled with the members assembled.
- (e) Connections. All shop and field connections of structural elements shall be bolted using high-strength steel bolts.
- (f) Bolts and Bolted Connections. Bolts and connections shall be as follows.
- (1) Turned Bolts. Turned bolts shall have a finishing cut. Holes for turned bolts shall be reamed or drilled 1/32 in. (1 mm) larger in diameter than the bolt. The threads of each turned bolt shall be entirely outside the grip of the metal. A washer 1/4 in. (6 mm) thick shall be used under each nut.
 - (2) High-Strength Steel Bolts. Bolted parts shall fit solidly together when assembled. Contact surfaces, including those adjacent to bolt heads, nuts, or washers, shall be free of all mill scale, dirt, burrs, and other defects that would prevent solid seating of all parts. Methods of installation and tightening shall be according to the "Specification for Structural Joints Using ASTM A 325 (A 325M) or A 490 (A 490M) Bolts", for slip-critical connections as issued by the Research Council on Structural Connections Joints of the Engineering Foundation, except as follows.

To insure solid seating of all parts of a slip-critical connection, no visible gap shall remain between the faying surfaces when all bolts are tightened to the snug tight condition, producing a bolt tension of approximately 10,000 lb (45 kN). All high-strength bolts shall have a

hardened washer under the element (nut or bolt head) turned in tightening, regardless of the method used in tightening.

Inspection will be according to the requirements of the latest issue of the "Specifications for Structural Joints using ASTM A 325 (A 325M) or A 490 (A 490M) Bolts" for slip-critical connections. The Contractor shall provide a calibration device capable of indicating bolt tension. The calibration device shall be capable of testing the shortest bolt length encountered on the structure down to the following minimum lengths.

Bolt Diameter	Minimum Length
5/8 and 3/4 in. (M16 and M20)	2 in. (50 mm)
7/8 in. (M22)	2.25 in. (60 mm)
1 in. (M26)	2.5 in. (65 mm)

The following fastening systems and installation methods will be allowed as options for all high-strength bolted connections: load indicating washer system, twist-off type fastener system, lock-pin and collar type fastener system, and turn-of-the-nut method. The Calibrated Wrench method will not be permitted.

The Contractor shall furnish a calibrated dial inspection torque wrench for use by the Engineer.

In addition to the field Rotation Capacity tests required in Article 505.04(f)(3)g.1., prior to its actual installation, a representative sample of not less than three fasteners of each diameter, length, and grade will be tested at the job site in the calibration device for approval. This field test will be performed according to the Procedure for Installation and Tightening for the particular fastening system as set forth in the Department's Construction Manual. Each powered tool to be used in the actual field installation will be used for at least one of the samples tested. Each worker who is to perform actual field installation will be required to perform and pass at least one of the sample tests, using the same equipment and methods that will be used for the actual field installation. Any worker who undertightens or overtightens the fastener during the test will not be allowed to perform actual field installation unless they perform a successful retest. If any fastener fails to meet the required minimum tension, the lot it was taken from will be rejected.

After all erection pins are removed, the fasteners in all holes of the connection shall be initially brought to a snug tight condition, approximately 10,000 lb (45 kN), progressing systematically from the most rigid part of the connection to the free edges in a manner minimizing relaxation of previously tightened fasteners. When testing for acceptance, the torque corresponding to the snug tight condition may be verified on the calibration device prior to failure.

After all fasteners in the connection are snug tight, they shall be fully tightened progressing systematically from the center most rigid part of the connection to its free edges.

For the twist-off or lock-pin and collar type fastener systems, the fractured end of the fastener, where the splined or pintailed end broke away, shall be cleaned with a wire brush or power tool prior to painting. After cleaning, the exposed end shall be given one coat of an approved high-build aluminum epoxy mastic and then painted with the paint specified for field painting the structure. The minimum dry film thickness of the aluminum epoxy mastic coating shall be 5.0 mils (125 microns).

The fastening systems shall meet the following requirements.

- a. Load Indicating Washer System. The direct tension indicator shall be according to ASTM F 959, except the average gap for giving the required minimum bolt tension shall be 0.005 in. (125 micron) for galvanized bolts.
 1. Testing. The calibration device shall have an adapter for checking the direct tension indicator when placed under the bolt head. The bolts shall be assembled with the direct tension indicator as they are to be installed in the field, including lubrication. Both the turn required by the impact wrench and the tension in lb (kN) shall be determined at snug tight, 0.015 and 0.005 in. (380 and 125 micron) gaps. This calibration test shall demonstrate that each bolt develops a tension not less than five percent greater than the tension required when the direct tension indicator average gap is 0.005 in. (125 micron). Average gap shall be measured according to Table 4 of ASTM F 959-06. If the bolt does not develop the minimum required tension at 0.005 in. (125 micron) gap with the direct tension indicator, the lot represented by the direct tension indicator will be rejected.
 2. Installation. The galvanized direct tension indicator shall be assembled under the bolt head with the protrusions bearing against the underside of the bolt head and shall not be placed under the element turned for tightening. A galvanized hardened washer shall be provided under the nut. For plain finished bolts the direct tension indicator may be placed under either the bolt head or the nut. A hardened washer shall be used between the direct tension indicator and the turned element with the protrusions bearing against the hardened washer.

The Engineer will check the gap with gap gauges. The Contractor shall supply a sufficient number of 0.001, 0.005 and 0.015 in. (25, 125 and 380 micron) gauges for inspection purposes.

Torque wrenches shall only be used as needed for verification purposes. Overtightening may produce total zero gaps. Total zero gap occurs when a 0.001 in. (25 micron) feeler gauge cannot enter any gap in the direct indicating washer. No more than ten percent of the bolts with total zero gap in any one connection will be allowed. If the number of total zero gap bolts exceeds ten percent of the bolts in the connection, a sufficient number of these bolts shall be removed and replaced to bring the percent within the ten percent allowed. No more than ten percent of the galvanized bolts will be allowed per connection with gaps between 0.005 and 0.015 in. (125 and 380 micron) or over 0.015 in. (380 micron) for plain finish bolts. If there are more than ten percent of these bolts per connection, additional tightening will be required to reduce the number of excessive gaps to less than ten percent of the total number of bolts. The Engineer will check 100 percent of the gaps of the first two connections with feeler gauges for each bolting crew. Testing at 100 percent will continue if the bolt tightening does not meet the above requirements. Once the above bolting requirements are met, a minimum of 20 percent but not less than ten bolts of each connection, and only one bolt of each cross frame or diaphragm connection will be tested with feeler gauges. The remainder of the bolts will be visually inspected. If ten percent of this sampling is total zero gap or ten percent greater than 0.005 in. (125 micron) gap, the entire connection will be tested.

- b. Twist-Off Type Fastener System. This method of joint assembly and tightening of connections shall be achieved by the use of a twist-off type fastener system meeting the requirements of section 2(d) of the "Specifications for Structural Joints using ASTM A 325 (A 325M) or A 490 (A 490M) Bolts". The twist-off bolts shall consist of a threaded bolt with a splined end extension that shears off at a given torque.
- c. Lock-Pin and Collar Type Fastener System. This method of joint assembly and tightening of connections shall be achieved by the use of a lock-pin and collar type fastener system meeting the requirements of section 2(d) of the "Specifications for Structural Joints using ASTM A 325 (A 325M) or A 490 (A 490M) Bolts". The lock-pin shall be round headed with a pintail that yields at a given load, and the collars shall be of the flanged type and equipped with tablocks to prevent slipping during installation.

A galvanized hardened washer according to AASHTO M 293 may be used under the bolt head for joint thickness adjustment, provided the installed fastener conforms to the maximum permissible dimensions "A" and "B" from inspection charts provided by the supplier. Loose or relaxed fasteners shall be removed and replaced with new fasteners. Each fastener will be visually inspected according to the inspection charts provided by the supplier.

The "A" dimension from inspection charts provided by the supplier may be increased to 1/8 in. (3 mm) and still meet all published values, provided there is no requirement to meet ASTM specifications pertaining to locking grooves (threads) in the shear plane.

A properly installed high-tensile fastener shall possess the dimensional characteristics from inspection charts provided by the supplier. Should the dimensions "A" or "B" exceed the indicated values, the fastener is being used out-of-grip. A "C" dimension of less than the values specified is an indication of incomplete swage. A "D" dimension exceeding the tabulated values is an indication of an incorrect or worn anvil on the installation tool. Fasteners falling outside of these ranges shall be removed and replaced.

- d. Turn-of-the-Nut Method. This method of joint assembly shall be according to Section 8(d)(1) of the "Specifications for Structural Joints using ASTM A 325 (A 325M) or A 490 (A 490M) Bolts", except as follows.

1. Installation. After all bolts in a connection are brought to a "snug tight" condition, the outer face of the nut shall be match-marked with the protruding portion of the bolt to visually determine the relative rotation occurring between the bolt and the nut during the process of final tightening. The wrench operator shall make marks with a permanent ink type marker or other approved means.

For connections with individual plates 1 in. (25 mm) and thicker, a minimum of two cycles of systematic snug tightening will be required to minimize relaxation of previously tightened fasteners prior to final tightening.

2. Inspection. Bolts tightened by the Turn-of-the Nut Method may be accepted by the Engineer on the basis of a visual inspection of the match-marks on the bolts.
- (3) Rotational Capacity tests for High-Strength Steel Bolts. Rotational Capacity tests are required for the Turn-of-the-Nut Method, Load Indicating washer, and Twist-Off type fastener Systems.

- a. Manufacturing. Hardness for bolt diameters 1/2 in. to 1 in. (M16 to M36) inclusive shall be as follows.

Bolt Size (Inclusive)	Hardness Number			
	Brinell		Rockwell C	
1/2 to 1 in.	Min.	Max.	Min.	Max.
	248	311	24	33
M16 to M36	Vickers		Rockwell	
	Min.	Max.	Min.	Max.
	255	336	C23	C34

- b. Testing. For galvanized washers, hardness testing shall be performed after galvanizing. The coating shall be removed prior to taking hardness measurements.

Rotational-capacity tests shall be required and will be performed on all black or galvanized (after galvanizing) bolt, nut, and washer assemblies by the manufacturer or distributor, and the following requirements shall be met prior to shipping.

1. The rotational-capacity test shall be performed according to AASHTO M 164 (M 164M).
2. Each combination of bolt production lot, nut lot, and washer lot shall be tested as an assembly.
3. A rotational-capacity lot number shall be assigned to each combination of lots tested.
4. The minimum frequency of testing shall be two assemblies per rotational-capacity lot.
5. The bolt, nut, and washer assembly shall be assembled in a Skidmore-Wilhelm Calibrator or an acceptable equivalent device.

Bolts too short to test in a tension calibrating device shall be tested in a steel joint. The tension requirement specified in Article 505.04(f)(3)b.7. need not apply. The maximum torque requirement specified in Article 505.04(f)(3)b.8. shall be computed using a value of P equal to the turn test tension shown in the table in Article 505.04(f)(3)b.7.

6. The minimum rotation, from an initially tightened condition (ten percent of the installation tension), shall be as follows.

Bolt Length	Minimum Rotation
≤ 4 bolt diameters	240° (2/3 turn)
>4 and ≤ 8 bolt diameters	360° (1 turn)
> 8 bolt diameters	480° (1 1/3 turn)

7. The tension reached at the above rotation shall be equal to or greater than 1.15 times the required installation tension. The installation tension and the tension for the turn test for ASTM A 325 (A 325M) bolts shall be as follows.

Diameter (in.)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
Installation Tension (kips)	12	19	28	39	51	56	71	85	104
Turn Test Tension (kips)	14	22	32	45	59	64	82	98	120

Diameter (mm)	16	20	22	24	27	30	36
Installation Tension (kN)	94	147	182	212	275	337	490
Turn Test Tension (kN)	108	169	209	244	316	388	564

8. After the required installation tension listed above has been exceeded, one reading of tension and torque shall be taken and recorded. The torque value shall conform to the following.

Torque shall be less than or equal to 0.25 PD.

Where: Torque = measured torque ft lb (kN m)
 P = measured bolt tension lb (kN)
 D = bolt diameter ft (m)

- c. Reporting. Reporting of tests shall be as follows.

1. The results of all tests specified including zinc coating thickness and the appropriate AASHTO tests shall be documented.
 2. Location where tests are performed and data of tests shall be documented.
- d. Witnessing. The tests need not be witnessed by an inspection agency. The manufacturer or distributor that performs the tests shall certify the results recorded as accurate.

e. Documentation. Documentation of tests shall be as follows.

1. Mill Test Report(s) (MTR).

- (a.) MTR shall be furnished for all mill steel used in the manufacture of bolts, nuts, or washers.
- (b.) MTR shall indicate where the material was melted and manufactured.

2. Manufacturer Certified Test Report(s) (MCTR).

- (a.) The manufacturer of the bolts, nuts, and washers shall furnish MCTR for the item furnished.
- (b.) Each MCTR shall show the relevant information according to the reporting of the testing required.
- (c.) The manufacturer performing the rotational-capacity test shall include on the MCTR the following information.
 - (1.) The lot number of each of the items tested.
 - (2.) The rotational-capacity lot number according to Article 505.04(f)(3)b.3.
 - (3.) The results of the tests required in Article 505.04(f)(3)b.
 - (4.) The information required in Article 505.04(f)(3)c.
 - (5.) A statement that MCTR for the items are according to this specification and the appropriate AASHTO specifications.
 - (6.) The location where the bolt assembly components were manufactured.

3. Distributor Certified Test Report(s) (DCTR). The DCTR shall include the following.

- (a.) Include MCTR above for the various bolt assembly components.
- (b.) Include rotational-capacity tests by either the manufacturer or the distributor.
- (c.) Show the results of the tests required in Article 505.04(f)(3)b.

- (d.) Show the pertinent information required in Article 505.04(f)(3)c.
 - (e.) Show the rotational-capacity lot number as required in Article 505.04(f)(3)b.3.
 - (f.) Shall certify that the MCTR are in conformance to this specification and the appropriate AASHTO specifications.
- f. Shipping. Shipping shall be as follows.
- 1. Bolts, nuts, and washers from each rotational-capacity lot shall be shipped in the same container. When there is only one production lot number for each size of nut and washer, the nuts and washers may be shipped in separate containers. Each container shall be permanently marked with the rotational-capacity lot number such that identification will be possible at any stage prior to installation. The rotational-capacity lot number shall be placed on both the container itself and the lid.
 - 2. The appropriate MTR, MCTR, or DCTR shall be supplied to the Engineer.
- g. Installation. The following requirements for installation shall apply prior to the installation of high-strength bolts.
- 1. The rotational-capacity test described in Article 505.04(f)(3)b. above shall be performed on each rotational-capacity lot at each job site prior to the start of bolt installation. If any bolt fails to meet the required minimum tension, the lot from which it was taken will be rejected.
 - 2. Lubrication.
 - (a.) Galvanized nuts shall be checked to verify that a visible lubricant is on the threads.
 - (b.) Black bolts shall be "oily" to the touch when delivered and installed.
 - (c.) Slightly weathered or lightly rusted bolts or nuts that fail to meet the above requirements shall be cleaned and relubricated prior to testing. Recleaned or relubricated bolt, nut, and washer assemblies shall be retested according to the rotational-capacity test, prior to final installation.
 - 3. Bolt, nut, and washer combinations as installed shall be from the same rotational-capacity lot.

- (g) Shop Assembling. Flange splice plates shall be fabricated with the primary rolling direction parallel to the member's longitudinal centerline. Web splice plates, connecting plates, gusset plates, and stiffeners may have their primary rolling direction in either direction. Parts of a member shall be assembled, well pinned and/or firmly drawn together with bolts before reaming or tightening of fasteners is commenced. The member shall be free from twists, bends, and other deformations that would prevent the solid seating required under Article 505.04(f)(2). A 1/8 in. (3 mm) or greater difference in plate thickness or member depths across a bolted splice shall be rectified with shims included during reaming, match marked, and shipped with member.

Parts not completely fastened in the shop shall be secured insofar as practicable to prevent damage in shipment and handling. Members assembled in the shop for reaming of field connections shall remain assembled until shop inspection by the Department has been made.

Fitting-up and shipping bolts, templates, jigs, shipping or shop assembly braces, and other items provided by the shop for fabrication or shipping but not incorporated in the final structure are considered incidental to the fabrication of the steel and will not be paid for as structural steel.

- (h) Drifting of Holes. The drifting done during shop assembly shall bring parts into position, but shall neither enlarge the full-size holes nor induce permanent distortion in any portions of the final structure.
- (i) Match Making. All parts of connections reamed or drilled in assembly shall be individually match marked while assembled and a diagram showing such marks shall be included in the shop detail drawings. Individually match marked items shall not be interchanged.
- (j) Stamping of Members for Identification. Any metal die stamping of steel members shall be done using low or mini-stress dies. Letters and numbers shall be 3/8 or 1/2 in. (10 or 13 mm) tall. When used, the dies shall be lightly struck to produce an impression that can be clearly seen in the absence of paint and mill scale.
- (k) Thermal Cutting. Structural steel or wrought iron may be thermally cut, provided that a smooth, accurate profile, free from cracks and notches, is obtained by the use of a mechanical guide. Hand cutting of material remaining in the final structure shall be done only where approved by the Engineer, and shall be followed by grinding.

Reentrant cuts shall have a radius of not less than 3/4 in. (20 mm) and be finished to an ANSI surface roughness not exceeding 500 μ in. (13 μ m).

Surface roughness exceeding the applicable limits of Article 505.04(l)(2) or the BWC and gouges not more than 3/16 in. (5 mm) deep on thermal cut edges (TCEs) shall be removed by machining or grinding and be faired to the surface with a slope of 1 to 10 or less. Material surface defects and gouges due to thermal cutting or handling damage that are more than 3/16 in. (5 mm) deep may be repaired according to the BWC using a

procedure approved by the Engineer for the material type and thickness involved. The completed weld shall be ground to match the adjacent surface and nondestructively inspected by magnetic particle or ultrasonic testing, as approved by the Engineer.

(I) Finishing.

- (1) Edge Planing. Sheared edges of material more than 5/8 in. (16 mm) thick and carrying calculated stress shall be planed to a depth of 1/4 in. (6 mm). Sheared edges of material up to 5/8 in. (16 mm) thick which carry calculated stress shall be planed to a depth of not less than 1/8 in. (3 mm) unless enclosed by welds. Sheared edges of material not carrying calculated stress and exposed after fabrication shall be ground or planed to remove evidence of tearing and sharp corners.
- (2) Facing of Bearing Surfaces. The top and bottom surfaces of steel pedestals, bolsters, column cap and base plates, and masonry (base) plates shall be planed or otherwise finished as necessary to be within 1/16 in. (2 mm) of planar. Cast pedestals shall be planed on surfaces that are to be in contact with steel and shall be finished to a maximum of ANSI roughness not exceeding 2000 μ in. (50 μ m) on surfaces in contact with masonry, leveling plates, or pads.

The surface finish of bearing and base plates and other bearing surfaces that come in contact shall meet the following requirements as defined in ANSI B 46.1, Surface Roughness, Waviness and Lay, Part 1.

Steel slabs	ANSI 2000 μ in.	50 μ m
Heavy plates in contact in shoes to be welded	ANSI 1000 μ in.	25 μ m
Milled or faced ends of compression members, milled or ground ends of stiffeners	ANSI 500 μ in.	13 μ m
Bridge rollers and rockers	ANSI 250 μ in.	6 μ m
Pin holes	ANSI 125 μ in.	3 μ m
Sliding self-lubricating bearings	ANSI 125 μ in.	3 μ m

Bronze or copper-alloy bearing plates shall be self-lubricated by special graphited and metallic inserts. The manufacturer's proposed materials and methods for producing the bearing plate shall meet with the approval of the Engineer.

- (3) Abutting Joints. Abutting joints in compression members shall be faced and brought into uniform bearing, with no gaps exceeding 1/32 in. (1 mm), before welding or producing full-size holes during shop assembly. Abutting joints in tension members and at beam or girder splices need not be faced but the clearance within field bolted connections shall be from 1/16 to 1/4 in. (2 to 6 mm).

- (4) End Connection Angles. End connection angles of floor beams and stringers shall be coplanar and positioned for the length of the member with such accuracy that milling to the exact member length will not reduce their thickness by more than 1/8 in. (3 mm).
- (5) Corner Grinding. All outside corners remaining after shop fabrication shall be free of abrupt irregularities and dull to the touch. Fins, burrs, cutting slag, significant deformities, gouges, sharpness (corner more acute than 1/32 in. (1 mm)) radius, and other hazards to handling or impediments to proper coating application and performance shall be corrected by grinding and/or other Engineer-approved methods. When painting is required, it shall be done according to Section 506.
- (6) Fit of Stiffeners. For bolted construction, end stiffener angles of girders and stiffener angles intended as supports for concentrated loads shall be milled or ground to secure an even bearing against the flange angles or beam flanges with no gaps exceeding 1/32 in. (1 mm).

For welded construction, bearing stiffeners shall be milled or ground to bear at the bearing ends and a tight fit provided at the other ends.

- (m) Links. Links for pin and link hanger assemblies or bearings experiencing uplift shall be fabricated from rolled plate. The primary plate rolling direction shall be along the length (vertical axis) of the link. The material shall have a minimum Charpy V-Notch toughness of 35 ft lb at 20 °F (48 J at -7 °C) and a minimum elongation of 22 percent in 2 in. (50 mm). Nominal yield strength of the link material shall not exceed 70 ksi (480,000 kPa). The links shall be straight and parallel. Holes in links and webs for pins or bushings shall have a maximum roughness equivalent to 125 μ in. (3 μ m) finish.
- (n) Rollers and Pins. Rollers and pins shall be straight and turned to the dimensions shown on the drawings. The final surface shall be produced by a finishing cut, except expansion rollers made from cold finished steel bars having a smooth, true surface, need not be turned. Pins for pin and link assemblies or bearings with uplift shall have a ground finish equivalent to a 32 μ in. (0.8 μ m) maximum roughness and shall be 100 percent inspected by magnetic particle or dye penetrant testing after grinding. Any cracks or other flaws detected shall be reported to the Engineer and will be cause for rejection. After testing, unpainted carbon steel pins shall be coated for corrosion protection according to Article 506.04(h). Rollers shall be shop primed after testing.
- (o) Boring Pin Holes. Pin holes shall be bored at right angles with the axis of the member and parallel to each other, unless otherwise required. The actual distance from center to center of pins at link connections shall not vary from that specified by more than 1/8 in. (3 mm). The boring shall be done after the member is fabricated. If metallic pin bushings are required, they shall be shrink fit and their internal diameters shall be ground to 32 μ in. (0.8 μ m) maximum roughness.
- (p) Pin Clearances. For steel-on-steel contact, the fit between a hole and a pin shall be according to ANSI Standard B4, Class RC8, loose running fit. For

pins bearing on metallic shrink fit bushings, the fit shall be ANSI Standard B4, Class RC7. For pins bearing on Teflon Impregnated fiber reinforced bushings, the bushing manufacturer's recommended tolerances for fit shall be followed for the hole and pin diameters. Tolerances for all pin diameters and pin holes shall satisfy the following.

Nominal Diameter	Range of Clearance	Tolerance from Nominal Sizes	
		Hole	Pin
in.	in. x 10 ⁻⁶	μ in.	μ in.
1.97-3.15	6.0-13.5	<u>+4.5</u> 0	<u>-6.0</u> -9.0
3.15-4.73	7.0-15.5	<u>+5.0</u> 0	<u>-7.0</u> -10.5
4.73-7.09	8.0-18.0	<u>+6.0</u> 0	<u>-8.0</u> -12.0
7.09-9.85	10.0-21.5	<u>+7.0</u> 0	<u>-10.0</u> -14.5
9.85-12.41	12.0-25.0	<u>+8.0</u> 0	<u>-12.0</u> -17.0
12.41-15.75	14.0-29.0	<u>+9.0</u> 0	<u>-14.0</u> -20.0

Nominal Diameter	Range of Clearance	Tolerance from Nominal Sizes	
		Hole	Pin
(mm)	(μm)	μm	μm
50-80	152-343	<u>+114</u> 0	<u>-152</u> -229
80-120	178-394	<u>+127</u> 0	<u>-178</u> -267
120-180	203-457	<u>+152</u> 0	<u>-203</u> -305
180-250	254-546	<u>+178</u> 0	<u>-254</u> -368
250-315	305-635	<u>+203</u> 0	<u>-305</u> -432
315-400	356-737	<u>+229</u> 0	<u>-356</u> -508

- (q) Welding. Welding shall be done according to the requirements of the ANSI/AASHTO/AWS D-1.5, except steel tubular structures shall be covered by the AWS D1.1 Structural Welding Code. Steel shall only be shop welded to remedy minor defects or according to details shown on shop drawings approved by the Engineer. Proposed details and procedures for field welding of structural steel shall be approved by the Engineer before welding begins.

Shop and field welding shall be performed using Welding Procedure Specifications approved by the Engineer with shielded metal arc welding (SMAW), submerged arc welding (SAW), gas metal arc welding (GMAW), or flux cored arc welding (FCAW) consumables permitted by the BWC. Other processes or consumables shall be specifically authorized by the Engineer on a project by project basis. Welders shall be qualified according to the BWC or Structural Welding Code.

(1) Modifications by Code. The following modifications to the specified sections of BWC shall apply.

- a. In sections 4 and 5 of the BWC, including tables 4.1, 4.2, 4.3, and 4.4, the base metals shown in each row of the following list shall be considered equivalent for the purposes of fabrication and weld procedure qualifications.

English

Row	ASTM Specification		AASHTO Specification	
	Previous	Current	Previous	Current
1	A 36	A 709 Gr. 36	M 183	M 270 Gr. 36
2	A 572 Gr. 50	A 709 Gr. 50	M 223 Gr. 50	M 270 Gr. 50
3	A588	A 709 Gr. 50W	M 233	M270 Gr. 50W
4	Note 1	A 709 Gr. HPS 70W	Note 1	M 270 Gr. HPS 70W
5	A 514	A 709 Gr. 100W	Note 1	M 270 Gr. 100
6	A 517	A 709 Gr. 100	M 244	M 270 Gr. 100

Note 1. Previous specification deleted.

(Metric)

Row	ASTM Specification		AASHTO Specification	
	Previous	Current	Previous	Current
1	A 36M	A 709M Gr. 250	M 183M	M 270M Gr. 250
2	A 572M Gr. 345	A 709M Gr. 345	M 223M Gr. 345	M 270M Gr. 345W
3	A 588M	A 709M Gr. 345W	M 222M	M 270M Gr. 345W
4	Note 1	A 709M Gr. HPS 485W	Note 1	M 270M Gr. HPS 485W
5	A 514M	A 709M Gr. 690W	Note 1	M 270M Gr. 690W
6	A 517M	A 709M Gr. 690W	M 244M	M 270 M Gr. 690

Note 1. Previous specification deleted.

Charpy-V-notch (CVN) Testing: All CVN testing shall be for Zone 2.

- b. In Section 5 of the BWC, 5.2 requires the Contractor to perform Qualification or Verification testing. The Department will consider each fabrication organization as a separate Contractor for this requirement of the BWC. For fabricators operating in multiple

locations, either with a group of buildings or at geographically separates facilities, weld procedures for the same type of equipment, used under similar operating conditions may be based on a common set of Procedure Qualification Reports (PQRs). If routine nondestructive testing reveals significant disparities in production quality that may be attributed to equipment variation then separate qualification tests shall be done at each location or machine involved. Non-FCM PQRs based on qualification tests, pretests, and/or verification tests shall remain valid as long as no significant changes occur in electrode/flux components or properties, subject to evidence of the shop's successful use of the process on equal or greater strength material at least every six months. If more than six months elapse without documented successful use of the process, the Engineer may require requalification of the PQR used to prepare the Weld Procedure Specification (WPS) proposed. Evidence of satisfactory use shall include Fracture Critical procedure tests, nondestructive examination of production welds, or welder/weld operator qualification tests. The Engineer will accept evidence of prior testing provided the PQR is complete and shows compliance with these specifications, and both the witnesses and the facility performing testing are satisfactory.

- c. Ancillary products described by subparagraph 1.3.6 of the BWC shall include: cross frames and diaphragms for non-curved structures and not designed to convey liveload stresses, expansion seal joints, pedestals and bolsters, retainer angles, walkway grating, and other items specifically identified by the Engineer.
- (2) Electrodes and Flux. Welding electrodes and flux for submerged arc welding shall bear the manufacturer's marking showing the material to be of the proper class. The equipment and consumables to be used shall be submitted to the Engineer for approval, together with evidence of the manufacturer's PQR and the Contractor's verification test(s) or the Contractor's PQR, except as exempted.

For flux cored electrodes, only E7XT-6 or E7XT-8 may be used in areas susceptible to drafts or wind exceeding 5 mph (8 km/hr). Other flux cored, metal cored, or solid electrodes utilizing gas shielding and satisfying the BWC may be used in enclosed, protected environments with air movement of less than 5 mph (8 km/hr). Welds made with E7XT-6 or E7XT-8 shall not be covered by or incorporated into welds made with other electrodes.

Electrodes and flux used for welding tubular steel structures and which satisfy prequalification requirements in the AWS D1.1 shall not require qualification testing.

When PQR, Pretests, and/or Verification Tests are not required, variables affecting heat input shall be within ranges specified by consumable manufacturers, and supported by manufacturers' compliance reports, not more than 12 months old, which shall be in a

file maintained by the Contractor and furnished to the Engineer or Inspector upon request. Any parameters (including gas flow, current limits, E.S.O., and polarity) not within the manufacturer's guidelines shall require qualification testing for the WPS. The Quality Assurance (QA) Inspector representing the Department and Contractor's Quality Control (QC) Inspector shall ensure the Procedure Qualification Test weld parameter variables are being accurately monitored and recorded for each pass, and that specimen identity is constantly maintained. Similarly, the QA Inspector and QC Inspector shall assure the critical weld parameters (preheat, travel speed, wire feed speed, current, etc.), consumable condition, and weld quality are adequately monitored throughout production.

When repetitive welding deficiencies persist even after adjustments are made, the QA Inspector shall have authority to prohibit use of the WPS, consumables involved, welding equipment and/or welding personnel, as applicable, for Department projects, until abnormalities are corrected to the QA Inspector's satisfaction. Such deficiencies may include: lack of fusion or penetration, overlap, large or frequent slag inclusions, poor deslagging and interpass cleaning, ropiness, convexity or concavity of bead, gross porosity, and non-uniform weld size. If more serious deficiencies are noted, such as weld or underbead cracking, extensive lack of fusion, wet flux, contaminated weld zone, or not conforming to an approved WPS, the QA Inspector may require either removal of questionable welds or additional NDT. If deficiencies are attributable to the WPS or a specific electrode-flux combination, the Engineer will have authority to require the Contractor to either repeat Qualification Testing or to use another approved WPS.

- (3) Procedures. Complete Weld Procedure Specifications (WPSs) shall be submitted to the Engineer with fully documented and accepted PQRs (if applicable) for approval. The WPS submitted may be either generic for common situations on multiple projects or be tailored to suit the particular fabrication project.

The WPS shall include the following items: general instructions for fit-up, techniques and welding sequences; types of steel; joint description and preparations; welding position; polarity; amperage, voltage, and linear welding speed; electrode size and type; flux designation and consumable manufacturer's trade name(s); approximate number of passes, maximum width and thickness of weld layers, and any procedure change between passes in the same weld; preheat-interpass temperatures, maximum and minimum; post heat temperature and duration; and other data necessary to fully describe the welding procedure. A copy of the WPS shall be available at the welding operation.

- (4) Welder Qualification. All welders, welding operators, and tackers shall be qualified by test according to the applicable welding code. Testing shall be administered and certified by a Certified Welding Inspector (CWI) or equivalent acceptable to the Engineer. The Engineer may

accept evidence of previous qualification for welders under the applicable welding specifications.

- (5) Fabrication. Shop welded butt splices, not detailed on Contract plans but required by limiting lengths of material, may be used if they are detailed for the full strength of the member and are placed at locations approved by the Engineer. Complete joint penetration welds shall not have more than three repair welds made at a common location. Complete removal of the weld and adjacent base metal shall be required after the third repair.

Flange-to-web welds and shop welded splices in flanges or webs shall use the automatic submerged arc welding process. All fillet welding of stiffeners and connection plates to webs shall utilize automatic submerged arc welding, unless otherwise approved by the Engineer for specific situations.

If the applicable code permits welding on areas with tight mill scale present, WPSs utilizing consumables with sufficient deoxidizing capacity shall be employed to avoid porosity or lack of fusion. Tack welds shall start a minimum of 3 in. (75 mm) from the end and shall be a minimum of 1 1/2 in. (40 mm).

Ends of fillet welds shall have full throat and no unfilled craters. Fillet welds on stiffeners, connecting plates, gussets, and other assemblies (except for flange-to-web welds) shall terminate approximately 1/4 in. (6 mm) from the end of plate intersects to avoid undercut and other defects.

Special precautions shall be taken when welding during cold weather to avoid extreme thermal gradients and to avoid adversely effecting the manual functions of the welder or welding operator. In certain cases, the BWC minimum preheat and interpass temperatures may be insufficient for steels with nominal yield strengths exceeding 50 ksi (345,000 kPa) and thickness above 3/4 in. (20 mm). Preheat for these steels shall be calculated if the nominal welding electrode strength exceeds 80 ksi (550,000 kPa) and the plate sulfur content exceeds 0.01 percent, or if either plate's carbon equivalent exceed 0.4 percent.

Tolerances for welded components shall be according to the applicable welding code, except the maximum deviation from specified camber for a span (abutment-to-pier or pier-to-pier) or girder segment (abutment-to-splice or splice-to-splice) shall be $\pm 3/4$ in. (± 20 mm).

Shop butt welds in flanges and webs shall be completed, tested, and accepted before the flanges are assembled on the web. Where possible, extension blocks (run on/run-off tabs) matching the joint's cross section are to be used for all complete penetration welds and flange-to-web welds, unless additional material is provided to ensure full size welds the full length of the member.

- (6) Inspection. The inspection of welds and workmanship will be performed according to the BWC, except as modified.

Prior to the start of fabrication of their first project for the Department, within the previous 24 months, the Contractor's QC and production supervisors and the Engineer shall have a conference to ensure agreement regarding the details of the project, standard shop procedures, advance notifications to the Inspector, specific items for QC/QA acceptance, material documentation, cleaning and painting requirements, the sequence of fabrication to be followed, the status of qualifications for welders and welding operators, and approval of electrodes, wire, flux, other welding materials, and equipment.

The welding and testing of all Procedure Qualification Test specimens shall be witnessed by personnel from two separate agencies, independent of the fabricator and acceptable to the Engineer. These may include the Inspector, Inspectors from other state DOTs, and/or qualified individuals from independent testing agencies which meet the approval of the Engineer.

Butt welds shall be radiographically (RT) or ultrasonically (UT) inspected according to the BWC, except: top and bottom 1/3 of each vertical web joint shall receive RT, and the remainder of that joint shall receive RT if unacceptable discontinuities are found in those areas; 50 percent of longitudinal web joints shall receive RT; and, except for webs, joints shall be considered "subject to tension or reversal of stress" if either plate joined requires Charpy V-notch (CVN) testing. In addition, butt welds in which the thickness of the thinner plate equals or exceeds 3 in. (75 mm) shall also receive UT. All joints to be inspected shall be free of paint, scale oil, and grease.

All radiographs shall be taken and interpreted by qualified technicians acceptable to the Engineer. The original film and a complete report describing the procedure and the technicians interpretation, properly identified as to piece and location of the weld, shall be submitted to the QA Inspector for approval prior to acceptance of the weld. If the original film is found to be unacceptable by review by the QA Inspector, another radiograph of the joint shall be taken. In the event the Contractor questions the QA Inspector's interpretation of the radiographic films, a joint review of the film will be made. The Engineer's final interpretation will govern.

When areas to be radiographed are too large for one film, overlapping exposures shall be made to cover the area. The limits for one film shall be 15 in. (375 mm) for web shots and 16 in. (400 mm) for flange shots 1 1/4 in. (30 mm) and thicker the limits shall be 15 in. (375 mm).

If radiographic inspections disclose rejectable defects, they shall be repaired and additional radiographs shall be taken for each repaired weld and submitted to the QA Inspector for approval.

The Contractor shall furnish the Engineer a shop drawing with the weld identification and showing assembly of the steel into final members or pieces. Lettering on radiographs of repairs shall show an "R" and the number of the repair shot. This additional identification shall be placed next to the film number and be included on the weld identification shop drawing.

Location marks shall be stamped in the steel by the Contractor prior to radiographing, using a prick punch with a dull tip. These will be located by lead arrows, but only the "floating" mark must be visible on the film. The location marks shall consist of center punch marks 1 1/2 in. (40 mm) from the centerline of the weld for plates up to 3 in. (75 mm) thick or 2 in. (50 mm) from the centerline on thicker plates, and 2 1/4 in. (60 mm) in from each edge of the plate. In addition, there shall be one randomly placed, "floating" punch mark within each exposure at the same distance from the centerline. The punch marks shall be placed in the thinner plate. In a series of overlapping exposures, the location marks shall be placed at approximately every 15 in. (375 mm).

Complete penetration tee and corner joints of primary members shall be ultrasonically inspected. Complete penetration tee and corner joints in compression or shear shall have at least 1 ft (300 mm) of every 4 ft (1.2 m) and 1 ft (300 mm) of each joint less than 4 ft (1.2 m) ultrasonically inspected. This shall include flange-to-web welds in bending members and welds joining material that does not require Charpy V-notch (CVN) testing. If unacceptable defects are found in any test length, the full length of the weld or 3 ft (900 mm) either side of the test length, whichever is less, shall be ultrasonically inspected. If unacceptable defects are found in more than 20 percent of the 1 ft (300 mm) increment lengths tested, the full length of the joint shall be ultrasonically inspected. Complete penetration tee and corner joints subject to tension or stress reversal shall be ultrasonically inspected the full length of the joint. This shall include welds joining plates requiring CVN testing other than web-to-flange joints in bending members. Welds within 1 ft (300 mm) of repairs shall be retested after the repairs are made.

Partial magnetic particle inspection will be required of each fillet weld on nonfracture critical girders, floor beams, stringers and truss members, fabricated items subjected to tensile stress or reversal of stress, including fingerplate stools, and for root and final passes of partial penetration groove welds in primary members, unless specifically exempted by the Engineer. At least 1 ft (300 mm) of every 10 ft (3 m) of weld length or 1 ft (300 mm) of each weld less than 10 ft (3 m) in length, plus welds within 1 ft (300 mm) of all starts and stops shall be tested, except bearing assembly to flange and diaphragm seat angle to web welds shall only be tested when visual inspection indicates possible flaws. The test shall be located at random in the members so as to be typical of the welding. Random locations are subject to selection by the Engineer. If unacceptable defects are found in any test length of a fillet weld, the full length of the weld, or 5 ft (1.5 m) on either side of the test length, whichever is lesser, shall be magnetic particle tested.

For Fracture Critical Members (FCM), fillet welds on flanges and webs that may be in tension areas shall receive 100 percent magnetic particle inspection.

The magnetic inspection procedure and techniques shall be according to ASTM E 709. The QA Inspector will examine the magnetic test reports and give approval before the members will be accepted. Welds within 1 ft (300 mm) of repairs shall be retested after the repairs are made.

Welded or cast steel bearing assemblies weighing more than 350 lb (160 kg) each shall be nondestructively examined by visual, magnetic particle and/or ultrasonic methods, as directed by the Engineer to insure no critical flaws exist.

Surface porosity in all welds shall not exceed 3/16 in. in 1 in. (5 mm in 25 mm) of weld nor 3/8 in. in 1 ft (10 mm in 300 mm) of weld. Cluster porosity size shall be determined by describing a circle around the cluster of holes. If the circle diameter is 3/16 in. (5 mm) or greater, the porosity must be ground out and rewelded. For linear porosity, a line connecting three or more adjacent pores shall be drawn. Adjacent pores are defined as pores separated by less than 1/4 in. (5 mm). If the line drawn exceeds 3/8 in. in 1 ft (10 mm in 300 mm), the porosity shall be ground out and rewelded. The maximum diameter for a single pore shall not exceed 3/32 in. (2 mm). The maximum frequency shall not exceed 1 porosity episode in 4 in. (100 mm) nor 5 (6) episodes for every 4 ft (1.2 m) of weld. The above criteria shall also apply to all subsurface welds which are critical or heavily stressed welds that are subjected to various nondestructive tests.

The Contractor shall give the Engineer sufficient advance notice of the date on which the material will receive radiographic, ultrasonic, or magnetic particle inspection so that the Engineer may be present.

- (r) Bent Material. Material that must be bent, shall be produced by techniques approved by the Engineer.
- (s) Fillers. Fills less than 1/4 in. (6 mm) thick may employ sheet steel material such as ASTM A 570 or A 606 satisfying the physical and weathering or coating requirements of the material joined. Fills shall not be tack welded.
- (t) Screw Threads. Threads for all bolts and pins for structural steel construction shall be according to the Unified Standard Series UNC-ANSI B 1.1, Class 2A for external threads and Class 2B for internal threads, except pins ends having a diameter of 1 3/8 in. (35 mm) or more shall have a thread pitch of 6 threads to the 1 in. (4.2 mm).
- (u) Anchor Bolts. Anchor bolts shall be according to Article 521.06.

505.05 Inspection. All material and workmanship will be subject to QA inspection by the Engineer. The cost of inspection, both at mill and shop, will be

borne by the Department, except whenever any inspection is conducted outside the Continental United States, the Contractor shall bear the actual costs of travel and subsistence for the Department's QA inspection.

- (a) Shop Inspection. The Contractor shall give the Engineer at least a one week notice prior to the beginning of work for shops within Illinois, and at least two weeks notice for work outside state boundaries. The Contractor shall arrange members or units to be inspected so that identification marks are visible and each member or unit is accessible for measurements the QA Inspector may deem necessary. Upon the QA Inspector's request, the Contractor shall reposition the steel to permit full examination. Prior to shop inspection of an item, the Contractor shall furnish the QA Inspector with a list of its main stress carrying material, correlating the piece mark and heat numbers. The heat number, established by the rolling mill, shall be preserved on material through fabrication until the element is joined into a member with a permanent piece mark.
- (b) Shop Assembly. All trusses and arches shall be completely, geometrically, or sequentially assembled at the fabricating plant, subject to the Engineer's approval of the fabricator's proposed system. Continuous beams or girders and connections requiring reamed field connection holes shall be assembled, unless otherwise noted or approved by the Engineer before reaming is commenced. For girder or beam lines with more than three elements, at least three pieces shall be included in each assembly. Unless approved by the Engineer, assemblies made for reaming or drilling holes shall not be disassembled until after shop QA inspection has been made. Shop assembly of curved girders shall meet the additional requirements of Article 505.04(c)(4).
- (c) Waiving Shop Inspection. The Engineer may partially or completely waive shop QA inspection and complete the inspection of fabricated material when it is delivered at the job site. The Contractor shall remain responsible for the fabricated items until job site acceptance is given.

505.06 Cleaning and Painting. When specified, structural steel shall be cleaned and painted according to Section 506. All high-strength bolts and other connectors, including nuts and washers, shall be mechanically galvanized according to Article 1006.08(a).

505.07 Marking and Shipping. Each member shall receive an erection mark for identification, and an erection diagram showing member locations shall be included in the shop drawings. If paint is used to locate (circle) metal stamped marks or to enhance their legibility (copy) on unpainted structures, the marks shall be placed in areas not highly visible after construction. Paint marks on outside faces of unpainted fascia members or on the underside of their bottom flanges shall be removed prior to shipping.

Pins, small parts, and small packages of bolts, washers, and nuts may be combined for shipment in boxes, crates, kegs, or barrels, but they shall be protected from damage and the gross weight of any container shall not exceed 300 lb (135 kg). A list and description of the contents shall be attached to the outside of each container. The loading, transportation, unloading, and storing of structural material

shall be conducted so that the items will be kept clean and not be excessively stressed, deformed or otherwise damaged. For handling long steel members or large assemblies, lifting points, temporary supports and sequences, based on the Contractor's calculations, shall insure member stresses do not exceed 80 percent of the material's minimum yield strength. These calculations shall be submitted to the Engineer for review. In storing and shipping members, blocking, bracing, and shoring shall be sized and placed as necessary to prevent excessive deflection or motion. Fabricated beams and girders shall be handled, stored, and shipped in an upright and final erection position unless otherwise approved by the Engineer.

Steel lifting lugs on members will not be permitted if their installation and removal could possibly be detrimental to the structure. The following requirements shall also be met.

- (a) One Contract for Fabrication and Erection. When fabrication and erection are accomplished under one contract and lifting lugs are used, the lugs shall be placed during fabrication. When no longer required, the lugs shall be removed.

The location, attachment, and removal method for the lugs shall be detailed on the shop drawings approved by the Engineer.

- (b) Separate Contracts for Fabrication and Erection. When fabrication and erection are accomplished under separate contracts and lifting lugs are desired by the erector but not shown on the contract plans, the erection Contractor shall be responsible for submittal of shop drawings to the Engineer for approval and for having the lugs furnished, installed and removed. When lifting lugs are detailed on the contract plans, the fabrication Contractor shall be responsible for furnishing and installing the lugs and the erection Contractor shall remove them when no longer required. The location, attachment, and removal method for the lugs shall be detailed on the shop drawings and approved by the Engineer.

505.08 Erection. The Contractor shall erect the structural steel, remove the temporary construction associated with the steel erection and do all work required to complete the structure as covered by the contract. The following requirements shall govern.

- (a) Concrete Work. If the substructure and superstructure are built under separate contracts, the Department will provide the substructure is within allowable tolerances for lines and elevations, and properly finished, and will establish the locations and elevations required for setting the steel.
- (b) Plant. The Contractor shall provide the falsework and all tools, machinery and appliances, including pilot and driving nuts, cylindrical erection pins, and fitting-up bolts, necessary for the expeditious handling of the work. These items will be considered as equipment and shall remain the property of the Contractor.
- (c) Handling and Storing. The loading, transporting, unloading, storing, and handling of structural steel shall be according to Article 505.07 and shall be conducted so that the members will be kept clean and free from injury.

When unloaded, the materials shall be placed on skids and braced to prevent excessive deflection, to keep the member off the ground and to provide adequate stability.

If the contract covering the erection of the steel does not include the fabrication, the erection Contractor shall check the material received and report promptly, in writing to the Engineer, any shortage or injury discovered. The erection Contractor shall be responsible for the loss of any material furnished by the Department or another Contractor after delivery and acceptance at the job-site, or for any damage to such material during job-site storage or erection.

- (d) Falsework. The falsework shall be designed, constructed, and maintained for the required loads and site conditions. The Contractor shall submit detailed plans for falsework, prepared and sealed by an Illinois Licensed Structural Engineer, for examination by the Engineer. If such plans are not satisfactory to the Engineer, the Contractor shall make such changes in them as may be required.
- (e) Methods and Equipment. Before starting work, the Contractor shall submit an erection plan to the Engineer for approval detailing the proposed methods of erection and the amount, location(s), and type(s) of equipment to be used.
- (f) Fixed Bearings. Fixed bearings on concrete shall be set level and not be placed upon areas that are improperly finished, damaged, or irregular.

Leveling plates, pads, and/or adjustment shims shall be placed beneath the bottom bearing plates or castings.

Anchor bolts shall be installed according to Article 521.06.

- (g) Straightening Bent Material. The straightening of plates, angles, and other shapes and built-up members, when permitted by the Engineer, shall be done by methods that will not produce fracture or additional injury. Distorted members shall be straightened by mechanical means or, if approved by the Engineer, by the careful planned and supervised application of a limited amount of localized heat, under rigidly controlled procedures. Procedures using heat, with or without external restraints (jacks, come-alongs), shall be detailed to include heat patterns and locations, maximum temperatures, monitoring methods, restraint locations, and calculations of restraint forces.

Before beginning any work, these shall be submitted and received for the approval of the Engineer. For AASHTO M 270 (M 270M) Grades 70W, 100, or 100W (485W, 690 or 690W) steels, the temperature shall not exceed 1050 °F (565 °C), and for other steels, the temperature of the heated area shall not exceed 1150 °F (620 °C) as verified by temperature indicating crayons, infrared or bimetal thermometers. Parts to be heat straightened shall be substantially free of stress from external forces, except the preplanned restraints in the Engineer-approved proposal. Following the straightening of a bend or buckle, the surface of the metal shall be carefully

inspected, and any evidence of fracture shall be immediately reported to the Engineer.

- (h) Assembling Steel. Match marks shall be followed and beams or girders supported to provide the top of beam/web elevations shown on contract plans (without steel dead load deflection) until field splices are pinned and partially bolted.

Bearing surfaces and surfaces to be in permanent contact shall be cleaned of foreign material before the members are assembled. Detailed truss spans erection procedures shall be submitted for the Engineer's approval. These shall include blocking and falsework plans, assembly sequence and bolting methods for chords, floor beams, stringers and bracing installation.

Bolted field splices in continuous beams or girders shall not be torqued until the entire continuous length is in place on the substructure. During erection, splices and field connections shall have 1/4 of the holes filled with finger-tight bolts and 1/4 with cylindrical erection pins. Bolt tightening shall not commence until all erection pins at a splice have been removed and all holes are filled with finger-tight bolts. Bolt tightening shall be according to Article 505.04(f). Temporary fitting-up bolts shall be the same diameter as the specified bolts, and cylindrical erection pins shall be 1/32 in. (1 mm) smaller than the hole.

- (i) Field Bolting. High-strength bolts shall be tested and installed according to Article 505.04(f). Drifting shall draw the parts into position but not enlarge the holes or distort the metal.
- (j) Other Bolted Connections. In connections, where bolts or turned bolts are used, the bolts shall be brought to snug tight and loosening shall be prevented by either burring the threads at the face of the nut with a pointed tool or other mechanical means, including lockwashers and self locking nuts.
- (k) Pin Connections. Pilot and driving nuts shall be used if required for driving pins. Pins shall be installed so that the members will take full bearing on them. Pin nuts shall be tightened sufficiently to limit lateral separation of material to 1/8 in. (3 mm) or that detailed by the contract plans, but not enough to clamp material and restrict rotation. Pins shall be double nutted with jam nuts or have other provisions to prevent loosening of single nuts under normal service conditions, subject to approval by the Engineer.
- (l) Misfits. The correction of misfits involving minor field corrections will be considered a part of the erection. Minor field corrections include grinding corners, burrs, or other small areas, removing less than 1/8 in. (3 mm) of material, or reaming of less than five percent of holes. Plates shall either be held tightly together during reaming or disassembled for cleaning. Any error in the shop fabrication or permanent deformation resulting from handling and transportation, which prevents the proper assembling and fitting up of parts by the use of cylindrical erection pins, or by minor field corrections, shall be reported immediately to the Engineer. Any proposed method of correction must be approved by the Engineer, and the correction shall be made in the Engineer's presence. If the contract provides for complete fabrication and

erection, the Contractor shall be responsible for all misfits, errors, and injuries, and shall make the necessary corrections and replacements. If the contract provides for complete fabrication of the steel, the Contractor performing the fabrication shall be responsible for all errors in fabrication. The Engineer will determine: what corrections are considered to be of a minor nature and are included as part of the erection work; what damage or loss is the responsibility of the erection Contractor; and which problems are to be considered errors in fabrication, to be remedied at the expense of the Contractor responsible for the fabrication. Damage occurring during transportation shall be corrected at the expense of the responsible Contractor.

- (m) Stud Shear Connectors. Stud shear connectors shall be furnished as a single unit and of a design suitable for end-welding to steel with automatically timed stud welding equipment. Stud shear connectors that are to be welded to the top flanges of beams or girders shall be placed after the steel has been erected and suitable scaffolding or the deck forming has been provided so the hazard due to stud projections is at a minimum. Studs that are to be welded to expansion guards, bearing plates, or other locations not posing a hazard, may be placed in the shop.

If flux-retaining caps are used, the steel for the caps shall be of a low carbon grade suitable for welding and shall comply with ASTM A 109 (A 109M). Finished studs shall be of uniform quality and condition, free from injurious laps, fins, seams, cracks, twists, bends, or other injurious defects.

Finish shall be as produced by cold drawing, cold rolling, or machining. The manufacturer shall certify that the studs satisfy the requirements of this Section. Certified copies of in-plant quality control test reports shall be furnished to the Engineer upon request. An arc shield (ferrule) of heat-resistant ceramic or other suitable material shall be furnished with each stud. The material shall not be detrimental to the welds or cause excessive slag and shall have sufficient strength so as not to crumble or break due to thermal structural shock before the weld is completed. Flux for welding shall be furnished with each stud, either attached to the end of the stud or combined with the arc shield for automatic application in the welding operation.

- (1) Power Source. Stud shear connections shall be end welded with automatically timed stud welding equipment connected to a suitable power source. If two or more stud welding guns are to be operated from the same power source, they shall be interlocked so that only one gun can operate at a time and so that the power source has fully recovered from making one weld before another weld is started.

Studs may be welded using two or more welding generators in parallel or by use of a battery operated source to supply the necessary amperage.

- (2) Preparation and Welding. At the time of welding, the studs shall be free of any rust, rust pits, scale oil, or deleterious matter. The surface to

receive the stud shall be free from mill scale and heavy rust. Paint, galvanizing and oil are contaminants and shall be removed.

Welding shall not be done when the base metal temperature is below 0 °F (-17 °C), or when the surface is wet. If it becomes necessary to weld the studs when the temperature of the base metal is below 0 °F (-17 °C), base metal shall be preheated and maintained above 32 °F (0 °C) during the welding operation.

While in operation, the welding gun shall be held in position without movement until the weld has solidified.

Longitudinal and lateral spacings of studs with respect to each other and to edges of beam or girder flanges shall not vary more than 1/2 in. (13 mm) from the dimensions shown on the plans, except that a variation of 1 in. (25 mm) will be permitted where required to avoid obstruction with other attachments on the beam. The minimum distance from the edge of a stud shank to the edge of a beam or plate shall be 1 in. (25 mm).

- (3) Inspection and Field Bend Tests. The first two studs welded on each beam or girder, after being allowed to cool, shall be bent 45 degrees by striking the stud with a hammer. If failure occurs in the weld of either stud, the procedure shall be corrected and 2 successive studs shall be successfully welded and tested before any more studs are welded to the beam or girder. This bend check shall also be made at the start of each day of the work, when the welding has been interrupted for an hour or more, when changing grounds, when changing weld settings or when changing cable loop due to arc blow (arc not going vertically from center stud to flange). In any case, no more than 500 studs shall be welded to a beam or girder without the welds being field bend tested according to the foregoing procedure. These bend tests shall be made by the operator and left in the bent position for inspection by the Engineer. All such studs that show no sign of failure as determined by the Engineer shall be left in the bent position. When 7/8 in. (22 mm) studs are welded, bend tests will be performed after every 250 studs. If due to low temperatures, preheating of the base metal has been utilized in preparation for automatic welding of studs to the beams or girders, the operator shall hammer bend to 45 degrees from the vertical two studs in each 100 welded in addition to the first two studs welded on each beam or girder. The studs shall be left in the bent position for examination by the Engineer.

Studs on which a full 360 degrees weld has not been obtained may, at the option of the Contractor, be repaired by adding a 5/16 in. (8 mm) fillet weld in place of the lack of weld, using the shielded metal-arc (SMAW) process with low hydrogen welding electrodes. The repair weld shall extend at least 3/8 in. (10 mm) beyond each end of the discontinuity being repaired. The minimum preheat (flange and stud temperature) for SMAW repair welds is 70 °F (20 °C). The Engineer will bend test questionable studs as follows: Using a heavy hammer the Engineer will strike the stud to bend in the direction opposite to the weld

deficiency until the shank is bent 15 degrees from the vertical (about 1 in. (25 mm) deflection). Then reversing direction, the stud will be driven back into the vertical position. If there is no visual distress evident in the weld, it will be considered satisfactory.

In addition to the bend tests accomplished by the operator to the satisfaction of the Engineer and the bend tests made by the Engineer, the Engineer will check approximately one percent of the studs at random by striking the stud and bending to an angle of 45 degrees with the vertical. The studs shall be left in the bent position.

If a stud fails or it becomes necessary to remove a stud with a defective weld, the vacated area of the beam or girder flange shall be ground smooth and flush. In the case of pullout of the base metal, the pocket or defect shall be ground smooth to a slope of 1:3 (V:H), with final striations parallel to the longitudinal axis of the beam or girder flange. Defects deeper than 1/4 in. (6 mm) shall be reported to the Engineer for further direction on repair requirements. The new stud shall be placed outside of, but within 1 in. (25 mm) of, the repaired area.

If the Engineer notes a reduction of the height of the studs as they are welded, the work shall be stopped immediately and not resumed until the cause has been corrected. If the Engineer determines that the shear connectors are not satisfactory by inspection and testing during the progress of the work, the Contractor shall replace all defective studs and make necessary changes in the welding procedure or welding equipment to secure satisfactory results.

- (n) Field Welding and Cutting. Field welding shall be according to Article 505.04(q) and all field thermal (flame or plasma) cutting shall be according to Article 505.04(k). No field welding shall be done on main, load carrying members unless specified by the contract plans or with the written permission of the Engineer. The use of thermal cutting in other areas will be permitted only when specified by the contract plans or authorized by the Engineer, and shall be subject to the Engineer's inspection. No thermal cutting equipment shall be permitted on the structure, except when in use according to the above requirements.
- (o) Construction Loads. Equipment for pulling falsework or other piles, for erecting adjacent structures, or for other tasks not directly related to construction of the structure shall not be operated upon or attached to any portion of the new structure without the written approval of the Engineer.

505.09 Work Under Separate Contracts. When the fabrication, erection, and painting of structural steel, construction of concrete decks, and other collateral work on a structure are accomplished under separate contracts, the following shall apply.

- (a) Storing and Protection of Structural Steel. When the fabrication, erection and painting of structural steel is accomplished under separate contracts, the fabrication Contractor shall be responsible for storing and protecting all fabricated structural steel up to 45 calendar days after completion dates,

delivery dates or number of working days specified in the fabrication contract. All storage costs incurred by the fabrication Contractor during this 45 day period shall be borne by the fabrication Contractor.

- (b) Shipping of Structural Steel to Jobsite. The erection Contractor shall provide the fabrication Contractor and the Engineer with a schedule for shipping the structural steel to the jobsite within 30 calendar days after the execution of the erection contract. This schedule shall specify the order items are to be received and their orientation for delivery, and must meet the approval of the Engineer. The erection Contractor will be responsible for receiving, unloading storing and protecting the structural steel in accordance with this schedule. If the erection Contractor elects to change this schedule, the erection Contractor shall be responsible for coordinating the change with the fabrication Contractor and for all costs and time delays associated with such changes.

Delivery of the structural steel to the jobsite shall be the responsibility of the fabrication Contractor. The mode of delivery shall be the option of the fabrication Contractor. Delivery shall be limited to the hours between 8:00 a.m. and 5:00 p.m. on weekdays only, excluding any observed holidays, unless otherwise approved by the Engineer. The erection Contractor shall be responsible for coordination of movement of the structural steel within the contract limits and shall be responsible for all demurrage charges. At the erection Contractor's option and expense, steel may be requested at times other than the stated time.

- (c) Installation of Minor Items. Minor items of fabricated steel that cannot be completely installed until either final adjustments are made or the completion of subsequent contracts, shall be delivered and partially erected or stored as directed by the Engineer. These items shall be installed or adjusted, as required, by the Contractor performing the subsequent work.

505.10 Field Painting. Steel structures shall be cleaned and field painted according to Articles 506.03 and 506.05.

505.11 Reserved.

505.12 Method of Measurement. All structural steel shown on the plans will be included for payment unless it is specifically included with a separate pay item. All other structure items, unless they are included with separate pay items or specified as included into other items, will be included as structural steel, and the weight will be calculated based upon their actual density (mass).

The Contractor performing the erection shall furnish the erection bolts and pins, and also pilot and driving nuts when required. The Contractor performing the fabrication shall furnish all fasteners, washers, shipping bolt, and fitting-up diaphragms when required.

When minor items of structural steel are specified for payment by weight, the weight used will be the measured weight (mass) of the fabricated structural steel furnished. No measurement will be made or allowed for the weight (mass) of field weld material. The structural steel will be measured in pounds (kilograms) using the

approved shipping weight (mass) or by measuring on approved platform scales. When the plan quantities of minor items of structural steel, such as expansion dams on concrete bridges or miscellaneous steel for the repair of existing structures, is approximately 10,000 lb (4500 kg) or less, the method of measurement for payment will be according to Article 202.07(a) unless a weigh ticket is provided.

505.13 Basis of Payment. Structural steel furnished and erected in place will be paid for at the lump sum price for FURNISHING AND ERECTING STRUCTURAL STEEL.

Fabricated structural steel furnished and delivered will be paid for at the lump sum price for FURNISHING STRUCTURAL STEEL.

Storage and care of the fabricated steel by the fabrication Contractor beyond the specified storage period, will be paid for at the contract unit price per calendar day for STORAGE OF STRUCTURAL STEEL if a pay item is provided for in the contract, or will be paid for according to Article 109.04 if a pay item is not provided in the contract.

Erected structural steel and other materials fabricated under this item will be paid for at the lump sum price for ERECTING STRUCTURAL STEEL.

If alterations or deductions to the work specified in the aforementioned lump sum items are ordered by the Engineer, the Contractor shall accept payment for any increase or decrease in the amount of structural steel and other materials according to Article 104.02(a). The unit price used for the adjusted work will be determined by dividing the lump sum price bid for the item by the Engineer's calculated weight as shown on the contract plans. No adjustment in this plan weight will be allowed in calculation of the unit price for the adjusted work. If the weight (Mass) in pounds (kilograms) for the increased or decreased amounts of structural metals ordered by the Engineer amounts to a change exceeding 0.5 percent of the Engineer's calculated weight as shown on the contract plans or 3000 lb (1360 kg), whichever is larger, the unit price used for the increased or decreased amount of structural steel shall be agreed upon by the Contractor and Engineer.

When specified, minor items of structural steel furnished and erected complete in-place will be paid for at the contract unit price per pound (kilogram) for FURNISHING AND ERECTING STRUCTURAL STEEL.

Stud shear connectors that are to be field welded to the top flanges of beams or girders will be paid for at the contract unit price per each for STUD SHEAR CONNECTORS.

SECTION 506. CLEANING AND PAINTING NEW STEEL STRUCTURES

506.01 Description. This work shall consist of the cleaning and preparation of new steel surfaces, and the furnishing, application, and protection of the paint coatings. The paint system shall be as shown on the plans and as specified herein.

506.02 Materials. Structural steel coatings shall be according to Section 1008. All coating materials to be used on an individual structure shall be produced by the same manufacturer.

506.03 Submittals. A minimum of 30 days prior to shop or field painting, the Contractor shall submit the following for the Engineer's review and acceptance: applicable plans, certifications, and information. Painting shall not commence until the submittals are accepted by the Engineer.

- (a) Shop Qualifications. The shop painting Contractor shall possess AISC Sophisticated Paint Endorsement or SSPC-QP3 certification, except for shops that only fabricate miscellaneous steel items such as bearings, side retainers, or expansion joint devices. Evidence of current qualifications shall be provided.
- (b) Field Qualifications. The field painting Contractor shall possess SSPC-QP1 certification. Evidence of current certification shall be provided. The Contractor shall maintain certified status throughout the duration of the painting work under the contract. For projects with less than 200 tons (180 metric tons) of fabricated steel, the Department will accept Contractors documented to be currently enrolled in the SSPC-QP7, Painting Contractor Introductory Program, in lieu of the QP certification noted above.
- (c) Quality Control (QC) Personnel Qualifications. Personnel managing the shop and field QC program(s) for this work shall possess a minimum classification of Society of Protective Coatings (SSPC) BCI certified, National Association of Corrosion Engineers (NACE) Coating Inspector Level 2-Certified, or shall provide evidence of successful inspection of three projects of similar or greater complexity and scope that have been completed in the last two years. Copies of the certification and/or experience shall be provided, including names, addresses, and telephone numbers of contact persons employed by the bridge owner.

The personnel performing the QC tests for this work shall be trained in coatings inspection and the use of the testing instruments. Documentation of training shall be provided. The QC personnel shall not perform hands on surface preparation or paint activities. Painters shall perform wet film thickness measurements, with QC personnel conducting random spot checks of the wet film. The Contractor shall not replace the QC personnel assigned to the project without advance notice to the Engineer, and acceptance of the replacement(s), by the Engineer.

- (d) Quality Control (QC) Program. The shop and field QC Programs shall identify the following: the instrumentation that will be used, a schedule of required measurements and observations, procedures for correcting unacceptable work, and procedures for improving surface preparation and painting quality as a result of quality control findings. The shop program shall include a copy of the QC form(s) that will be completed daily. The field program shall incorporate the IDOT Quality Control Daily Report form, as supplied by the Engineer.
- (e) Field Cleaning and Painting Inspection Access Plan. The plan shall identify the means of access that will be used by the Contractor QC personnel for ongoing inspections and by the Engineer during Quality Assurance (QA) observations.

- (f) **Surface Preparation/Painting Plan.** The surface preparation/painting plan shall include the methods of surface preparation and type of equipment to be utilized for solvent cleaning, abrasive blast cleaning, pressure washing, and power tool cleaning. The plan shall include the manufacturer's names of the materials that will be used, including product data sheets and Material Safety Data Sheets (MSDS).

A letter or written instructions from the coating manufacturer shall be included, indicating the required drying time for each coat at the minimum, normal, and maximum application temperatures before the coating can be exposed to temperatures or moisture conditions that are outside of the published application parameters. The paint used for erection marks shall be identified together with a letter from the coating manufacturer indicating that the marking material is compatible with the coating system. The coating manufacturer shall provide a letter that stipulates the thickness of the primer to be applied in slip-critical connections and required drying times prior to bolting. All application shall be performed according to the coating manufacturer's instructions.

- (g) **Containment Plan.** The Contractor shall evaluate project-specific conditions to determine the specific type and extent of containment needed to control the paint emissions and submit a plan for containing or controlling paint debris (droplets, spills, overspray, etc.).
- (h) **Chloride Removal.** Methods of chloride removal may include, but are not limited to, steam cleaning or pressure washing with or without the addition of a chemical soluble salt remover as approved by the coating manufacturer, and scrubbing. The Contractor shall provide the proposed procedures for chloride remediation in the Surface Preparation/Painting Plan. The frequency of testing shall also be included. Note: Chloride remediation is only required when the erected steel is exposed through the winter prior to field painting.

506.04 Quality Control and Quality Assurance. Quality Control and Quality Assurance shall be according to the following.

- (a) **Quality Control (QC) Inspections.** The Contractor shall perform first line, in-process, QC inspections of each phase of the work. The submitted and accepted QC Program(s) shall be used to insure that the accomplished work complies with these specifications. The shop painting Contractor shall use their forms as supplied in their submittal. These shop reports shall be made available for review when requested by the Engineer. The field painting Contractor shall use the IDOT Quality Control Daily Report form supplied by the Engineer to record the results of quality control tests. These field reports shall be submitted to the Engineer before work resumes the following day. The Engineer will sign the report as an acknowledgment that the report has been received.

The Contractor shall supply all necessary equipment to perform the QC inspections. Equipment shall include the following at a minimum.

- (1) Psychrometer or comparable equipment for the measurement of dew point and relative humidity, together with all necessary weather bureau tables or psychrometric charts.
- (2) Surface temperature thermometer.
- (3) Bresle Cell Kits or CHLOR*TEST kits for chloride determinations, or equivalent, when applicable.
- (4) Wet film thickness gauge.
- (5) Blotter paper for compressed air cleanliness checks.
- (6) Type 2 magnetic dry film thickness gauge per SSPC-PA2.
- (7) Calibration standards for dry film thickness gauge.
- (8) Light meter for measuring light intensity during cleaning, painting, and inspection activities.
- (9) All applicable ASTM and SSPC Standards used for the work.
- (10) Commercially available putty knife of a minimum thickness of 40 mils (1 mm) and a width between 1 and 3 in. (25 and 75 mm). (Only required in touch-up areas where the coating is being feathered and tested with a dull putty knife.)

The instruments shall be calibrated by the Contractor's personnel according to the equipment manufacturer's recommendations and the Contractor's QC Program. All inspection equipment shall be made available to the Engineer for QA observations on an as needed basis.

- (b) Quality Assurance (QA) Observations. The Engineer may conduct QA observations of any or all phases of the shop or field work.

506.05 Hold Point Notification for Field Painting. Specific inspection items throughout this specification are designated as (HOLD POINTS). The Contractor shall provide the Engineer with a minimum four-hour notification before a hold point inspection will be reached. If the four-hour notification is provided and the work is ready for inspection at that time, the Engineer will conduct the necessary observations. If the work is not ready at the appointed time, unless other arrangements are made, an additional four-hour notification is required. Permission to proceed beyond a hold point without a QA inspection will be granted solely at the discretion of the Engineer. The Engineer has the right to reject work that was performed without adequate provision for QA observation.

506.06 Inspection Access and Lighting. Inspection access and lighting shall be as follows.

- (a) Inspection Access. The Contractor shall facilitate the Engineer's observations as required, including allowing ample time to view the work. The Contractor shall furnish, erect, and move scaffolding or other

mechanical equipment to permit close observation of all surfaces to be cleaned and painted. This equipment shall be provided during all phases of the work. Examples of acceptable access structures include the following.

- (1) Mechanical lifting equipment such as scissor trucks, hydraulic booms, etc.
- (2) Platforms suspended from the structure comprised of trusses or other stiff supporting members and including rails and kick boards.
- (3) Simple catenary supports are permitted only if independent life lines for attaching a fall arrest system according to OSHA regulations are provided.

When the surface to be inspected is more than 6 ft (1.8 m) above the ground or water surface, and fall prevention is not provided (e.g. guardrails) the Contractor shall provide the Engineer with a safety harness and a lifeline. The lifeline and attachment shall not direct the fall into oncoming traffic. The Contractor shall provide a method of attaching the lifeline to the structure independent of the inspection facility. When the inspection facility is more than 30 in. (750 mm) above the ground, the Contractor shall provide an approved means of access.

- (b) Lighting. The field Contractor shall provide artificial lighting both inside and outside containment where natural light is inadequate, as determined by the Engineer, to allow proper cleaning, inspection, and painting. Illumination for inspection shall be at least 30 foot candles (325 lux). Illumination for cleaning and painting, including the working platforms, access, and entryways, shall be at least 20 foot candles (215 lux). General work area illumination outside the containment shall be employed at the discretion of the Engineer and shall be at least 5 foot candles (54 lux). The exterior lighting system shall be designed and operated so as to avoid glare that interferes with traffic, workers, and inspection personnel.

CONSTRUCTION REQUIREMENTS

506.07 Shop Cleaning New Structures. After fabrication, all steel surfaces except bolts, stainless steel, sliding surfaces, and items to be hot dip galvanized, shall be blast cleaned in the shop.

In addition to the requirements of Section 3.2.9 of the AASHTO/AWS D1.5/D1.5: Bridge Welding Code (breaking thermal cut corners of stress carrying members), rolled and thermal cut corners to be painted with zinc primer shall be broken if they are sharper than a 1/16 in. (1.5 mm) radius. Corners shall be broken by a single pass of a grinder or other suitable device at a 45 degree angle to each adjoining surface prior to final blast cleaning, so the resulting corner approximates a 1/16 in. (1.5 mm) or larger radius after blasting. Surface anomalies (burrs, fins, deformations) shall also be treated to meet this criteria before priming.

Prior to blast cleaning, dirt, oil, and grease shall be removed according to the requirements of SSPC-SP1 for Solvent Cleaning. Blast cleaning of areas to be shop

painted shall be accomplished according to the requirements of the SSPC Surface Preparation Specification SP10 for Near-White Blast Cleaning. Small areas may be cleaned according to SSPC Surface Preparation Specification SP11 for Power Tool Cleaning to Bare Metal. Areas of carbon steel to be blast cleaned but not shop painted shall satisfy the requirements of SSPC Surface Preparation Specification SP10 for Near-White Blast Cleaning.

All areas of weathering steel that are not to be shop painted shall satisfy the requirements of SSPC Surface Preparation Specification SP6, Commercial Blast Cleaning. After the painted areas have cured, unpainted surfaces shall be sprayed with a stream of potable water to ensure uniform weathering.

All blast cleaned surfaces to be shop painted shall have an anchor profile of 1.5 to 2.5 mils (35 to 65 μm).

506.08 Painting Systems for New Structures. One of the following paint systems shall be utilized as shown on the plans.

- (a) Inorganic Zinc-Rich/ Waterborne Acrylic Paint System. This system is designed for shop priming and field application of the intermediate and top coats. Shop application of the intermediate and top coats will not be allowed.

In the shop, all structural steel designated to be painted shall be given one coat of inorganic zinc rich primer. In the field, the structural steel shall receive one full intermediate coat and one full topcoat of waterborne acrylic paint.

- (b) Organic Zinc-Rich/ Epoxy/ Urethane Paint System. This system is designed for full shop application of the coating system, except for contact surfaces of field connections and portions of the fascia girders when specified. In the shop, all structural steel designated to be painted shall be given one coat of organic zinc rich primer. Prior to application of the intermediate and top coats, all contact surfaces shall be masked off. Intermediate and top coats shall be shop applied to all designated surfaces. A stripe coat of the urethane topcoat shall be applied to crevices and outside edges prior to the application of the full topcoat.

Field painting of this system shall be limited to all damaged areas, all installed fasteners, and any other areas left un-topcoated in the shop.

When fabrication and erection of structural steel are accomplished under separate contracts, the entire paint system shall be shop applied according to Article 506.08(a) as part of the fabrication contract.

The color of the topcoat shall be as specified elsewhere in the contract. For weathering steel the color of the topcoat shall match the Federal Color Standard 595a 20045.

506.09 Shop Painting New Structures. Before painting, all blast products shall be removed from the surfaces. The blast-cleaned surfaces to be painted shall be given a prime coat within 24 hours after cleaning. If rust forms on the surface, all

areas of rusting shall be recleaned prior to application of the primer. Surfaces shall comply with SSPC-SP10, Near-White Blast Cleaning at the time of painting, or SSPC-SP6, Commercial Blast Cleaning, for weathering steel. If slivers or laminations are found on the steel after blast cleaning, they shall be removed by grinding the surface prepared by abrasive blast cleaning to the specified degrees of cleaning, or by power tool cleaning according to SSPC-SP11, Power Tool Cleaning to Bare Metal. The quality of cleaning shall be accepted by the shop QC inspector and the Engineer prior to painting.

At the Contractor's option, hot-dip galvanizing may be substituted for shop priming of bearings, typical cross frames, or diaphragms on non-curved structures; expansion joint assemblies; and other elements not carrying calculated stress. Galvanized surfaces which will have concrete poured against them shall be chemically passivated or otherwise protected by a method approved by the Engineer. Galvanized bearings for exterior members and elements readily visible after erection shall be prepared for field painting, but galvanized items obscured from public view will not require field painting. If the Contractor elects to utilize galvanizing, a proposal shall be submitted to the Engineer, showing items to be galvanized with applicable provisions of AASHTO M 111, drain/vent holes, and any other necessary modifications. For galvanized items to be painted, the proposed method of surface preparation, and the coats to be applied shall also be addressed. Passivating treatments shall not be used on galvanized surfaces that will be painted.

The fabricated steel shall not be loaded for shipment to the job-site until the shop paint is cured for handling, and the steel and coating has been inspected and approved by the Engineer. No painting shall be done after the material has been loaded for shipment.

The shop painting of steel structures shall be according to the following requirements.

- (a) Paint. The shop applied portion of the paint system shall be according to Article 506.08(a) or (b), as specified on the plans.
- (b) Storage Temperature. The paint shall be stored at temperatures between 40 and 110 °F (5 and 43 °C) or the manufacturer's recommended limits, whichever are more restrictive. A permanent, automated record of storage temperatures shall be maintained and be available for the Engineer's review.
- (c) Mixing of Paint. The paint shall be thoroughly mixed with a power mixer before being applied and the pigments shall be kept in suspension. Records shall be maintained for every batch or kit of coating applied in the shop showing when the activator was added, when the last of each product was either applied or discarded, and what items were coated with each material. Inorganic zinc-rich primer, after initial mixing, shall be strained through a metal screen not coarser than 30 mesh (600 µm) or finer than 60 mesh (250 µm), before application.

Thinning will be permitted when required for proper application. The type of thinner used and the amount used shall be as recommended by the paint manufacturer for the ambient conditions. Any thinner additions (quantity and type) shall be documented on the record for each batch of coating. The

manufacturer's recommended pot life times shall not be exceeded, and coating applied after that limit shall be removed. Pot life and dry film thickness limits shall apply to spray, brush, or dauber application.

- (d) Weather Conditions. Coatings shall be applied within the temperature and relative humidity limits specified by the coating manufacturer's product data sheet. Work may be performed outside when the air speed is less than 5 mph (8 km/hr) and surface temperature is more than 5 °F (3 °C) above dew point. For indoor painting, adequate ventilation shall be provided. The surface of the steel shall be dry when the paint is applied. The relative humidity and ambient temperature ranges specified by the coating manufacturer for coating application shall be maintained for at least ten hours where steel is stored after painting is complete, or longer if stipulated by the manufacturer in the submittals provided in Article 506.03(f).

If the relative humidity for inorganic zinc-rich primer cannot be maintained above the manufacturer's recommended lower limit due to ambient conditions, alternate methods of ensuring proper cure may be proposed by the Contractor, accompanied by supporting recommendations from the coating manufacturer, for the Engineer's consideration. Documented records correlating the items coated, temperatures of paint and material during application, and the ambient temperature and relative humidity for painting and storage areas shall be maintained by the painting facility.

- (e) Application. Paints shall be applied by either airless or conventional spray methods, except areas inaccessible to spray and small touch-up areas may be painted by brush or dauber. When inorganic zinc primers are applied by brush or dauber, the size of the areas shall be minimized and the thickness carefully controlled to avoid mudcracking. When inorganic or organic zinc-rich primer is being spray applied, the material shall be kept under constant agitation with a power mixer to avoid settling. The applicable recommendations of the coating and spray equipment manufacturers as well as those of the SSPC-PA1, Shop, Field, and Maintenance Painting of Steel shall be followed for all shop painting.
- (f) Dry Film Thickness. The dry film thickness of each coat applied in the shop shall be measured according to SSPC-PA2, and comply with the ranges specified below. Areas of insufficient thickness shall receive additional coating, applied according to the manufacturer's written instructions. Excessive coating thickness shall be removed and repaired according to the manufacturer's written instructions. Methods proposed for the repair of insufficient or excessive thickness shall be accepted by the Engineer prior to implementation.

(1) Inorganic Zinc/Acrylic System Dry Film Thicknesses:

Inorganic Zinc/Acrylic System Dry Film Thickness		
Coating	Minimum Thickness	Maximum Thickness
Inorganic Zinc Primer (shop)	3 mils (75 μ m)	6 mils (150 μ m)
Aluminum Epoxy Mastic (field spot coat)	5 mils (125 μ m)	7 mils (175 μ m)
Acrylic Intermediate (field)	2 mils (50 μ m)	4 mils (100 μ m)
Acrylic Topcoat (field) ^{1/}	2 mils (50 μ m)	4 mils (100 μ m)
Total Thickness ^{2/}	7 mils (175 μ m)	14 mils (350 μ m)

1/ Stripe coat not measured.

2/ The total dry film thickness, excluding the spot areas touched up with aluminum epoxy mastic and stripe coat areas.

(2) Organic Zinc/Epoxy/Urethane System Dry Film Thicknesses:

Organic Zinc/Epoxy/Urethane System Dry Film Thickness		
Coating	Minimum Thickness	Maximum Thickness
Organic Zinc Primer (shop)	3 mils (75 μ m)	5 mils (125 μ m)
Epoxy Intermediate (shop or field spot coat as specified)	3 mils (75 μ m)	6 mils (150 μ m)
Aluminum Epoxy Mastic (field spot coat)	5 mils (125 μ m)	7 mils (175 μ m)
Aliphatic Urethane Topcoat (shop or field as specified) ^{1/}	2.5 mils (63 μ m)	4 mils (100 μ m)
Total Thickness ^{2/}	8.5 mils (213 μ m)	15 mils (375 μ m)

1/ Stripe coat not measured.

2/ The total dry film thickness, excluding the spot areas touched up with aluminum epoxy mastic and stripe coat areas.

(g) Field Connections and Faying, Contact, and Inaccessible Surfaces,

(1) All faying surfaces of field connections shall be masked off after priming and shall not receive the intermediate or top coats in the shop. The intermediate and top coats for field connections shall be applied in the field, after erection of the structural steel is completed.

(2) Surfaces in contact with each other at shop-bolted connections shall be cleaned and primed before bolting.

(h) Film Continuity. The shop coating shall be smooth and free of skips, misses, shadow-through, overspray, dryspray, runs, sags, and other film defects. Defective areas shall be repaired according to the manufacturer's written instructions, as accepted by the Engineer.

- (i) **Removal of Unsatisfactory Paint.** If all or a portion of the coating shows significant or widespread defects, evidence of having been applied under unfavorable conditions, or poor workmanship, the Engineer may order it removed and steel cleaned and repainted. Where "mud cracking" occurs in inorganic zinc-rich primer, it shall be removed to soundly bonded paint and re-coated if necessary for adequate dry film thickness. Areas adjacent to the removal of unsatisfactory paint shall be feathered to provide a smooth transition between original and re-applied paint. Recoating shall be according to the manufacturer's written instructions, as accepted by the Engineer.
- (j) **Surfaces in Contact with Concrete.** Top surfaces of painted beams and girders shall be given one shop coat of primer, except that portions where stud shear connectors are field installed shall not be painted. Unless hot dip galvanized, all portions of expansion guards (except anchor studs or bars), that are to be in contact with or partially embedded in concrete, shall be shop primed. When beam ends of weathering steel are embedded in concrete, only the shop primer shall be applied. Intermediate or topcoats shall not be applied.
- (k) **Machine-Finished Surfaces.** Machine-finished surfaces of pins, pin holes, or other sliding surfaces, except stainless steel, not to be painted shall be coated as soon as practicable after being approved, with lacquer or an anti-rust compound. When anti-rust compound is used, it shall be removed at the time of erection and a coating of a suitable lubricant approved by the Engineer shall be provided and applied by the erection Contractor before installation. Except for stainless steel which shall not be painted, machine-finished surfaces, and the ends, threaded parts, and nuts of pins exposed after erection shall be cleaned according to SSPC-SP1, Solvent Cleaning, painted with one coat of the paint used for spot painting, and then painted with the topcoat specified for field painting the structure.
- (l) **Bearing Surfaces.** All surfaces of rockers, bolsters, masonry (base) plates, and shims placed under masonry plates shall be given one coat of primer. Sole (top bearing) plates welded or bolted to members shall receive the same treatment as the member at that location.
- (m) **Erection Marks.** Erection match marks and member piece marks shall be legible when delivered to the jobsite. Contrasting paint may be used on areas that have received shop coating to identify locations of stamped marks or to duplicate their information. The paint used shall be the same as, or compatible with, the field topcoat. Paint marks used on unpainted steel shall not be in locations readily visible on the finished structure, such as the outside face of exterior members or the underside of bottom flanges. Marks in areas readily visible after erection shall be removed.

506.10 Field Cleaning and Painting New Structures. The requirements of Article 506.09, paragraphs (a) to (i), inclusive, together with the following shall also pertain when field-applying intermediate or final coats of paint on new steel, hereinafter referred to as "field painting."

- (a) Seasonal Restrictions on Field Cleaning and Painting. Field cleaning and painting work shall be accomplished between April 15 and October 31 unless authorized otherwise by the Engineer in writing.
- (b) Protection. Stainless steel and other surfaces designated in the plans or by the Engineer shall be protected from cleaning and painting.

Paint drips, spills, and overspray are not permitted to escape into the air or onto any other surfaces or surrounding property not intended to be painted. Containment shall be used to control paint drips, spills, and overspray, and shall be dropped and all equipment secured when sustained wind speeds of 40 mph (64 kph) or greater occur, unless the containment design necessitates action at lower wind speeds. When the containment needs to be attached to the structure, it shall be attached by clamping or similar means. Welding or drilling into the structure shall be prohibited unless otherwise approved by the Engineer in writing.

- (c) Field Surface Preparation (HOLD POINT). Before the application of the field coats, the shop coats and any newly installed fasteners shall be pressure washed as specified below to remove dirt, oil, lubricants, oxidation products, and foreign substances, followed by solvent cleaning per SSPC-SP1 as required.

All damaged shop coated areas and newly installed fasteners shall then be spot cleaned per SSPC-SP3. The surrounding coating at each repair location shall be feathered for a minimum distance of 1 1/2 in. (40 mm) to achieve a smooth transition between the prepared areas and the existing coating. The existing coating in the feathered area shall be roughened to insure proper adhesion of the repair.

The following processes shall be used to prepare the shop-coated steel surfaces for field painting. The Contractor shall notify the Engineer 24 hours in advance of beginning surface preparation operations.

- (1) Low Pressure Water Cleaning and Solvent Cleaning. Pressure washing shall involve the use of potable water at a minimum of 1000 psi (7 MPa) and less than 5000 psi (34 MPa) according to "Low Pressure Water Cleaning" of SSPC-SP12. Paint spray equipment shall not be used to perform the pressure washing. The cleaning shall be performed in such a manner as to remove dust, dirt, chalk, insect and animal nests, bird droppings, and other foreign matter prior to solvent cleaning.

When detergents or additives are used, the surface shall be rinsed with potable water before the detergent water dries. Pressure washing shall be completed no more than two weeks prior to painting.

After pressure washing has been accepted by the Engineer, all traces of asphaltic cement, oil, grease, diesel fuel deposits, and other soluble contaminants which remain on the steel surfaces to be painted shall be removed according to SSPC-SP1 Solvent Cleaning, supplemented with scraping (e.g., to remove large deposits of asphaltic cement) as required. All fasteners shall be thoroughly solvent cleaned. The

solvent(s) used for cleaning shall be compatible with the applied coating. The Contractor shall identify the proposed solvent(s) in the submittals. If the coating is softened, wrinkled, or shows other signs of attack from the solvents, the Contractor shall immediately discontinue their use. If solvent cleaning/scraping is not successful in removing the foreign matter, the Contractor shall use other methods identified in SSPC-SP1, such as steam cleaning as necessary.

- (2) Power Tool Cleaning of Shop-Coated Steel. Damaged and rusted areas shall be spot cleaned according to Power Tool Cleaning SSPC-SP3. Final power tool cleaning shall be performed no longer than 12 hours prior to painting. A power tool cleaned surface shall be free of all loose rust, loose and peeling paint, and loose rust that is bleeding through and/or penetrating the coating. All locations of visible corrosion and rust bleed, and lifting or loose paint shall be prepared using the power tools.

Upon completion of the cleaning, rust, rust bleed, and surrounding paint are permitted to remain if they cannot be lifted using a dull putty knife.

- (3) Pressure Washing Between Coats. When foreign matter has accumulated on a newly applied coat, pressure washing shall be performed prior to the application of subsequent coats.
- (d) Field Soluble Salt Remediation (HOLD POINT). If the erected steel is exposed to winter weather prior to field painting, the Contractor shall implement surface preparation procedures and processes that will remove chloride from the surfaces prior to field painting. Surfaces that may be contaminated with chloride include, but are not limited to, expansion joints and all areas that are subject to roadway splash or runoff such as fascia beams and stringers.

Upon completion of the chloride remediation steps, the Contractor shall use cell methods of field chloride extraction and test procedures (e.g., silver dichromate) accepted by the Engineer, to test representative surfaces for the presence of remaining chlorides. Test frequency shall be according to the approved submittals. Remaining chloride levels shall be no greater than 7 µg/sq cm as read directly from the surface without any multiplier applied to the results.

- (e) Surface and Weather Conditions (HOLD POINT). Surfaces to be painted shall be free of moisture and other contaminants. The Contractor shall control his/her operations to insure that dust, dirt, or moisture does not come in contact with surfaces painted that day.

Prepared surfaces shall meet the requirements of the respective degrees of cleaning immediately prior to painting, and shall be painted before rusting appears on the surface. If rust appears or bare steel remains unpainted for more than 12 hours, the affected area shall be prepared again.

The surface temperature shall be at least 5 °F (3 °C) above the dew point during final surface preparation operations. The paint manufacturer's

published literature shall be followed for specific temperature, dew point, and humidity restrictions during the application of each coat, and for the minimum and maximum time between coats.

The Contractor shall monitor temperature, dew point, and humidity every four hours during surface preparation and coating application in the specific areas where the work is being performed. The frequency of monitoring shall increase if weather conditions are changing.

(f) Field Painting. Field painting shall be as follows. (HOLD POINT)

(1) Field Painting for the Inorganic Zinc-Rich/Waterborne Acrylic Paint System. All damaged shop primed areas and all field installed fasteners shall be fully primed with epoxy mastic. The structural steel shall then receive one full intermediate coat and one full topcoat of waterborne acrylic. A stripe coat shall be applied to crevices and outside edges prior to the application of the full topcoat.

(2) Field Painting for the Organic Zinc-Rich/Epoxy/Urethane Paint System. All damaged areas and newly installed fasteners shall be fully primed with epoxy mastic. One intermediate coat of epoxy shall be applied over the epoxy mastic and on exposed shop primer. One topcoat of aliphatic urethane shall be applied to all areas where the intermediate coat is visible, whether the intermediate coat was applied in the shop or in the field. The field applied coats shall only overlap onto the existing top coat where sanding has been performed.

Where the intermediate coat, but not the urethane topcoat, is applied in the shop, all damaged areas and all newly installed fasteners shall be fully primed with epoxy mastic. The maximum recoat time for the intermediate coat shall be observed when applying the urethane topcoat. If the recoat time for the intermediate coat is exceeded, the Contractor shall submit for approval by the Engineer, written recommendations from the coating manufacturer for the procedures necessary to extend that recoat window or otherwise prepare the intermediate coat to receive the topcoat. A stripe coat of the urethane topcoat shall be applied to crevices and outside edges prior to the application of the full topcoat.

If either system is damaged after all coats are applied, damaged areas shall be prepared and feathered according to Article 506.10(c). The cleaned areas shall be spot painted with a penetrating sealer as recommended by the manufacturer, which shall overlap onto the existing topcoat in the feathered area. Then the aluminum epoxy mastic shall be spot applied not to go beyond the area painted with the sealer. The intermediate and topcoat shall be spot applied to the mastic.

(g) Methods and Sequence of Application. Paint may be applied by airless spray or with brushes. In addition, the use of rollers will be permitted in the application of paint coatings to flat surfaces, provided satisfactory results are obtained. If the structure includes a concrete deck, field painting at the job site shall be done after the deck is poured and the forms have been

removed and the surface pressure washed. Painting shall only be done when dirt, dust, or other material from cleaning operations will not fall or blow onto the coating. The painted areas shall be kept within the manufacturer's recommended temperature range and protected from moisture and contaminants until drying is achieved as stipulated by the manufacturer in the submittals.

The sequence of the work shall permit each coat to properly cure according to the manufacturer's requirements before the next coat is applied. In no case shall paint be applied until the previous coat has been inspected by the Engineer and its condition has been verified by the appropriate tests. Except as provided herein, field painting shall be done after the erection is completed. Surfaces that require field paint, but would be inaccessible after the erection is completed, shall be painted during either fabrication or erection as approved by the Engineer.

Surfaces that will have concrete poured against them and contact surfaces of bolted connections shall be shop primed only.

- (h) **Work Under Separate Contracts.** When field painting of structural steel is not part of the erection contract, the erection Contractor shall still be responsible for repairing any damage to the shop applied paint system as a result of the steel erection process. Field painting under a contract that does not include the erection shall include the cleaning and spot preparation necessary at the time the work is performed, and the additional spot and field paint coatings required.
- (i) **Painting Date/System Code.** At the completion of the work, the Contractor shall stencil, using a contrasting colored paint, the date of painting the bridge, the painting Contractor's name, and the paint type code from the Structure Information and Procedure Manual for the system used. The letters shall be capitals, not less than 2 in. (50 mm) and not more than 3 in. (75 mm) in height. When all coats are applied in the shop, the shop Contractor shall do the stenciling. When one or more coats are applied in the field, the field Contractor shall do the stenciling.

The stencil shall contain the following wording "PAINTED BY (insert the name of the painting Contractor)" and shall show the month and year in which the painting was completed, followed by "CODE" and the appropriate code number for the paint system applied, all stenciled on successive lines. This information shall be stenciled on the cover plate of a truss end post near the top of the railing, or on the outside face of an outside stringer near both ends of the bridge facing traffic, or at some equally visible surface designated by the Engineer.

506.11 Method of Measurement. Shop cleaning and painting new steel structures will not be measured for payment. Field cleaning and painting will not be measured for payment, except when performed under a contract that contains a separate pay item for this work.

When paid for as a separate item, cleaning and painting of steel railings will be measured for payment in place in feet (meters). The length measured will be the overall length along the top longitudinal rail element through all posts and gaps.

506.12 Basis of Payment. Cleaning and painting in connection with the fabrication and erection of steel structures will not be paid for separately but shall be considered as included in the contract unit price or prices for furnishing, fabricating and erecting, or installing the material.

The field cleaning and painting of newly erected structural steel under a contract separate from the fabrication and erection will be paid for at the lump sum price for **CLEANING AND PAINTING STRUCTURAL STEEL**, at the location specified. The field cleaning and painting of steel railings which are fabricated and erected at the contract unit price per foot (meter) will be paid for at the contract unit price per foot (meter) for **PAINTING STEEL RAILING** when performed under a contract separate from the erection.

SECTION 507. TIMBER STRUCTURES

507.01 Description. This work shall consist of timber construction required for bridges and appurtenances, where the timber is incorporated in the completed structure. All lumber and timber for erection purposes, such as falsework, forms, sheeting, bracing, etc., are not subject to the requirements of this Section.

507.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Structural Timber	1007.03
(b) Preservative Treatment	1007.12
(c) Fastenings for Timber Structures	1006.17
(d) Structural Steel	1006.04
(e) Asphalt Binder, Grade PG 52-28, PG 58-28 or PG 58-22 ..	1032.01 - 1032.05
(f) Fine Aggregate	1003.03
(g) Structural Steel Coatings	1008.01 - 1008.02

Structural steel and other metals requiring fabrication shall be fabricated according to Section 505.

CONSTRUCTION REQUIREMENTS

507.03 Storage of Materials. Untreated lumber at the site of the work shall be open-stacked on supports at least 12 in. (300 mm) above the ground and shall be so stacked and stripped as to permit free circulation of air between the tiers and courses. When required by the Engineer, it shall be protected from the weather by suitable covering. Treated timber shall be close-stacked according to Article 1007.13.

507.04 Workmanship. All timber shall be accurately cut and framed to a close fit in such manner that the joints will have even bearing over the entire contact surfaces. Nails and spikes shall be driven just sufficiently to set the heads flush with

the surface of the wood. Deep hammer marks in wood surfaces shall be considered evidence of poor workmanship.

507.05 Treated Timber. All cutting, framing and boring of treated timber shall be done before treatment insofar as is practicable.

- (a) Handling. Treated timber shall be handled carefully without sudden dropping, bruising, breaking of outer fibers or penetrating the surface with tools. It shall be handled with rope slings. Cant hooks, peaveys, pikes, or hooks shall not be used.
- (b) Cuts, Abrasions, and Holes. All cuts, abrasions, and holes made after treatment shall be repaired according to Article 1007.13. Each coat shall be allowed to dry before the next coat is applied. Any unfilled holes, after being treated with preservative, shall be plugged with treated plugs.
- (c) Temporary Attachments. Forms or temporary braces may be attached to treated timber with nails or spikes only when approved by the Engineer. Upon their removal, the holes shall be filled by driving galvanized nails or spikes flush with the surface, or by plugging as required for holes.

507.06 Countersinking. Countersinking shall be done wherever smooth faces are required. Recesses formed in treated timber for countersinking shall be treated as required for cuts and abrasions, except as specified for plank floors.

507.07 Hardware. The term hardware shall include all metal fastenings required for timber connections or for connecting timber to concrete or steel work. The following items will be considered as hardware: bolts, tie rods, turnbuckles, washers, nuts, drift bolts, steel dowels, nails, spikes, and lag screws for timber connections; steel plates used as washers or between timber caps and the tops of piles or timbers; metal timber connectors of various designs; metal shear developers for composite timber and concrete floors; and anchor plates or clips for plank floors and sidewalks. Sheet metal pile coverings and steel traffic treads and their fastenings are not considered hardware.

All hardware for treated timber construction, except cast iron ogee washers, malleable iron washers and timber connectors, shall be stainless steel or galvanized.

- (a) Rods. Rods connecting only sawed timbers shall be threaded sufficiently at each end to provide tight connections, allowing for permissible variations in dimensions of material. All rods shall extend entirely through the nut at each end and, after being drawn tight, all ends that project more than 1 in. (25 mm) beyond the nut shall be cut off about 1/2 in. (13 mm) beyond the nut.
- (b) Bolts. The length specified shall be the length measured under the head. Bolts may be substituted for rods for timber connections where the length of threaded portion provided by the bolt is sufficient. Bolt ends projecting more than 1 in. (25 mm) beyond the nut shall be cut off as specified for rods. Special flat head bolts, or carriage bolts, shall be used for connections horizontally through railings and wheel guard timbers, with the head at the

roadway face of the timbers. Machine bolts with square heads and nuts shall be used for other connections.

- (c) Lag Screws. Lag screws shall be installed by turning them into place. They may be driven sufficiently to start them into the holes and hold them firmly in place for turning, but shall not be driven beyond the depth that will be occupied by the shank.
- (d) Nuts and Washers. Washers shall be used under all nuts and bolt heads that would otherwise come in contact with wood, except under large diameter heads of specially designed flat head bolts. Ogee or malleable iron washers shall be used for all tie rods except where plate washers are called for by the plans, and for all rods and bolts passing through piles except bolts connecting railing plank to wing piles. Standard wrought washers shall be used at all locations, except where washers of other types are required. All nuts shall be standard square nuts. They shall be tightened sufficiently to prevent the rods or bolts from becoming loose during service and, after being tightened, they shall be effectively secured against backing off by burring of the rod or bolt threads.
- (e) Nails and Spikes. Nails shall not extend through all material into which they pass. The size of nails and spikes, when not otherwise shown, shall be according to the following.

Size of Nails and Spikes		
Actual Thickness of Piece Nailed in. (mm)	Actual Thickness of Piece Nailed to in. (mm)	Size of Nails and Spikes
1 5/8 (41)	1 5/8 (41)	10d
1 5/8 (41)	2 (50)	16d
1 5/8 (41)	2 5/8 (66) or more	20d
2 (50)	2 (50)	16d
2 (50)	2 5/8 (66) or more	20d
2 5/8 (66)	2 5/8 or 3 (66 or 75)	40d
2 5/8 (66)	3 5/8 (92) or more	60d
3 (75)	3 (75)	50d
3 (75)	3 5/8 (92) or more	60d
3 5/8 (92)	3 5/8 (92) Spikes	
4 (100)	3 5/8 (92) or more	7 in. (178 mm) spikes

507.08 Holes for Bolts, Dowels, Rods, and Lag Screws. Holes for round drift bolts and dowels shall be bored with a bit 1/16 in. (2 mm) less in diameter than the bolt or dowel to be used. The diameter of holes for square drift bolts or dowels shall be equal to the least dimension of the bolt or dowels. Holes for bolts shall be bored with a bit of the same diameter as the bolt. Holes for rods shall be bored with a bit 1/16 in. (2 mm) greater in diameter than the rod. Holes for lag screws shall be bored with a bit not larger than the body of the screw at the root of the thread. If required to prevent splitting, the hole for the shank shall be bored the same diameter

as the shank. The depth of holes for lag screws shall be a minimum of 1 in. (25 mm) less than the length under the head.

507.09 Pile Bents and Abutments. All work involving piles shall be according to Section 512. Cut-offs shall be made accurately to ensure complete bearing between the cap and piles, or good alignment of the tops of wing piles. No shimming between pile tops and caps will be permitted, except to provide for adjustment of not more than 1 in. (25 mm) required on account of errors in cut-off. The shim for this purpose shall consist of a single square steel plate of the proper thickness, having the same width as the cap, punched 1/16 in. (2 mm) larger than the drift bolt. The piles for any one bent or line shall be selected carefully as to size, to avoid undue bending or distortion of the bracing or backing timbers. Care shall be exercised in the distribution of piles of varying sizes to secure the required strength and rigidity throughout the structure.

507.10 Caps. Timber caps shall be placed, with ends aligned, in a manner to secure an even and uniform bearing on the tops of the supporting posts or piles. They shall be secured by a drift bolt not less than 3/4 in. (20 mm) in diameter, extending at least 9 in. (225 mm) into each post or pile. The drift bolt shall be as near the center of the post or pile as possible without interfering with rods passing through the post or pile near the cap. Caps shall not be spliced, except as provided by the plans.

507.11 Backing Plank. Backing plank shall be placed so that exposed ends form a straight line. They shall be fastened to each pile and nailing strip with at least two nails or spikes. Splices in backing plank shall be made at the center of a pile and splices in adjoining lines or plank shall be staggered. Backing plank for wings shall be placed so that the top of the top plank will be at the proper elevation.

507.12 Stringers. Timber stringers shall be placed in position so that the floor will have an even bearing on all stringers and so that any knots near edges will be in the top portions of the stringers. Outside stringers may have butt joints, centered over caps or floor beams, but interior stringers shall be lapped to take bearing over the full width of the cap or floor beams at each end. Stringers shall be toenailed to caps and intermediate stringers of adjoining spans shall be spiked together where they lap.

Cross-bridging between stringers shall be neatly and accurately framed, and securely toenailed with at least two nails in each end. All cross-bridging members shall have full bearing at each end against the sides of stringers. 2 in. (50 mm) by 4 in. (100 mm) cross-bridging shall be placed at the center of each span.

507.13 Plank Floors. The floor planks shall be laid at right angles to centerline of roadway. The planks shall be carefully graded as to thickness and laid so that no two adjacent planks will vary in thickness by more than 1/16 in. (2 mm). When more than one length of plank is required, joints between abutting ends shall be staggered at least 3 ft (1 m) in any two adjacent lines of plank. Ends of planks at the edges of the roadway shall be cut on a straight line parallel with the centerline of the roadway.

When plank floors on steel stringers are to be fastened to nailing strips bolted to the sides of the steel stringers, the top of each nailing strip shall be flush with the top

of the beam or channel. A recess of the proper width and depth shall be provided in the top surface of the nailing strip to fit neatly around the projecting flange of the beam or channel. Nailing strips for treated plank floors shall be so recessed before treatment.

In constructing floors of untreated material, the planks shall be laid heart side down with 1/4 in. (6 mm) joints between them for seasoned material and with tight joints for unseasoned material. Treated plank floors shall be laid with tight joints, except when the planks are separated by anchor clips used for fastening the planks to steel stringers.

Standard wrought washers shall be used under the heads of all lag screws and the heads or nuts of all machine bolts used for fastening the floor plank. Where machine bolts are used for fastening the floor plank, all nuts used shall be locknuts. Heads of all lag screws and bolts in the surface of the floor shall be countersunk so that the tops will be flush with the surface of the plank. Recesses formed for countersinking shall be just large enough to admit the washers and, after the lag screw or bolt is in place, shall be filled with hot pitch.

For laminated or strip floors, the strips shall be placed on edge and each strip shall be nailed to the preceding strip at each end with two nails and approximately at 18 in. (450 mm) intervals with nails driven alternately near the top and bottom edges. The nails shall be long enough to pass through two strips and at least halfway through the third strip. If timber stringers or nailing strips are used, every other strip shall be toenailed to every other support. Care shall be taken to have each strip vertical and tight against the preceding one, and bearing evenly on all supports.

507.14 Bituminous Surface Coat. When required, plank floors shall be given a bituminous surface coat. The floor shall be cleaned of foreign materials and the asphalt cement shall be applied at a temperature of from 275 to 350 °F (135 to 175 °C) and at a rate of approximately 1/4 gal/sq yd (1 L/sq m) of surface. The plank shall be dry at the time of this application. The entire surface shall then be covered with a thin coating of fine aggregate, sufficient in quantity to take up any free bitumen.

507.15 Steel Traffic Treads. Steel traffic treads shall be not less than 3/16 in. (5 mm) thick, exclusive of the raised portions, not less than 24 in. (600 mm) wide, and the individual sections not more than 15 ft (4.5 m) long. Treads shall have a non-skid surface with alternate projections at right angles to each other. The raised portions shall be formed in the rolling and not by punching or pressing from the under side. Treads shall be punched 7/16 in. (11 mm) for lag screws or bolts. The holes shall be placed not less than 1 1/4 in. (30 mm) nor more than 1 1/2 in. (40 mm) from the edge of the tread. The spacing of holes on both sides of the tread shall be not more than 15 in. (375 mm) and on both ends of each section not more than 6 in. (150 mm). The unit weight of the treads shall be approximately 8 3/4 lb/sq ft (43 kg/sq m).

Before the treads are laid, all high spots and rough spots in the plank floor shall be removed so that the treads will be in contact with the floor for their full length and width. Treads shall be laid in a heavy mop coat of hot asphalt according to Article 1032.11, PAF-3. Treads shall be laid with a space of 1/4 in. (5 mm) between adjacent ends and shall be fastened by means of 3/8 in. (M10) galvanized bolts. Where bolts cannot be installed, 3/8 in. by 3 in. (M10 by 75 mm) galvanized screws shall be used.

507.16 Wheel Guards and Railings. Wheel guards and railings shall be accurately framed so that they will be true to line and grade. Wheel guards shall be laid in sections not less than 12 ft (3.6 m) long with each splice located approximately over the center of a scupper block. Railing plank shall be untreated timber and shall be painted with two coats of white paint. Surfaces in contact with rail posts or piles shall be painted with one coat before the railing planks are erected.

507.17 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. The quantity of timber will be computed in foot, board measure (cubic meters). Computations of quantity will be based on the nominal commercial widths and thicknesses of the material. The length will be the actual lengths of the various pieces required, measured to the nearest 1 in. (25 mm). The length of each piece with a beveled end will be taken as the overall length of the piece, except that when two or more pieces with beveled ends may be cut economically from a single commercial length, the sum of the lengths will not exceed the commercial length required. The quantity computed for payment will include all splices required by the plans but will not include any allowance for additional splices or waste.

Hardware will be measured for payment in pounds (kilograms). The weight (mass) of rods and plates will be computed from the weights (masses) shown in the current edition of the American Institute of Steel Construction Manual, with no deduction for holes and no allowance for overrun. Weights (masses) computed from dimensions of material will be based upon a weight (mass) of 490 lb/cu ft (7850 kg/cu m) for steel, 485 lb/cu ft (7770 kg/cu m) for wrought iron, and 450 lb/cu ft (7200 kg/cu m) for cast iron. No additional allowance for loss or waste will be added to the computed weights (masses), but an additional allowance of 3 1/2 percent for galvanizing will be added to weights (masses) of all galvanized material computed on the basis of ungalvanized material.

Bituminous surface coat for plank floors will be measured for payment in square yards (square meters).

Steel traffic treads will be measured for payment in square feet (square meters).

507.18 Basis of Payment. Treated timber will be paid for at the contract unit price per foot board measure (cubic meter) for TREATED TIMBER. Untreated timber will be paid for at the contract unit price per foot board measure (cubic meter) for UNTREATED TIMBER. All items classed as hardware will be paid for at the contract unit price per pound (kilogram) for HARDWARE. Bituminous surface coat for plank floors will be paid for at the contract unit price per square yard (square meter) for BITUMINOUS SURFACE COAT. Steel traffic treads, including bolts, lag screws, or

other fastenings, will be paid for at the contract unit price per square foot (square meter) for STEEL TRAFFIC TREADS.

SECTION 508. REINFORCEMENT BARS

508.01 Description. This work shall consist of furnishing and placing reinforcement bars.

508.02 Materials. Materials shall be according to Article 1006.10.

CONSTRUCTION REQUIREMENTS

508.03 Storage and Protection. Reinforcement bars shall be stored off the ground using platforms, skids, or other supports; and shall be protected from mechanical injury and from deterioration by exposure. Epoxy coated bars shall be stored on wooden or padded steel cribbing and all systems for handling shall have padded contact areas. The bars or bundles shall not be dragged or dropped.

When epoxy coated bars are stored in a manner where they will be exposed to the weather more than 60 days prior to use, they shall be protected. The protection shall consist of covering with opaque polyethylene sheeting or other suitable opaque material. The covering shall be secured and allow for air circulation around the bars to minimize condensation under the cover.

Covering of the epoxy coated bars will not be required when the bars are installed and tied, or when they are partially incorporated into the concrete.

508.04 Cutting and Bending. Reinforcement bars shall be cut and bent at the mill or shop to the shapes shown on the plans before shipment to the work. Bending in the field will not be permitted, except to correct errors, damage by handling and shipping, and minor omissions in shop bending.

Epoxy-coated reinforcement bars that are specified to be cut in the field shall be either sawed or sheared but shall not be flame cut. Patching and repair of the cut, bent, or damaged epoxy coated reinforcement bars shall be completed using a two-part epoxy according to AASHTO M 317.

508.05 Placing and Securing. All reinforcement bars shall be placed and tied securely at the locations and in the configuration shown on the plans prior to the placement of concrete. Reinforcement bars shall not be placed by sticking or floating into place during or immediately after placement of the concrete.

Bars shall be tied at all intersections, except where the center to center dimension is less than 1 ft (300 mm) in each direction, in which case alternate intersections shall be tied. The number of ties as specified shall be doubled for lap splices at the stage construction line of concrete bridge decks when traffic is allowed on the first completed stage during the pouring of the second stage.

Prior to the placement of any concrete, all mortar or other foreign material shall be removed from the reinforcement. Placement of the concrete shall not commence

until the Engineer has inspected and approved the reinforcement placement. The Contractor shall correct any misalignment of the reinforcement bars occurring during the placement of the concrete.

The clearances from the face of the form shall be maintained by the use of chairs or other supports approved by the Engineer. Clearance from the bottom of footing shall be maintained by concrete blocks, cement bricks, suspended in place, or other support system approved by the Engineer. Pebbles, stones, building bricks, and wood blocks shall not be used for bar supports. Bars in the bottom of beams and girders shall be supported by chairs placed on the forms. In beams and girders having two or more layers of bars, the chairs for the upper layer shall rest on the immediate lower layer, top bars in beams and girders shall be supported from the adjacent slab or from the stirrups.

Supports shall be metal or plastic. Metal bar supports shall be made of cold-drawn wire, or other approved material and shall be either epoxy coated, galvanized or plastic tipped. When the reinforcement bars are epoxy coated, the metal supports shall be epoxy coated. The supports may be recycled plastic. Supports shall be provided in sufficient number and spaced to provide the required clearances. All supports shall meet the approval of the Engineer.

Bars in the bottom of concrete bridge decks shall be supported from the forms on continuous type bar supports placed transversely to the bottom bars at a maximum spacing of 3 ft 3 in. (1 m). Bars in the top of concrete bridge decks shall be supported on continuous high chairs placed transverse to the bottom bars of the top mat at a maximum spacing of 3 ft (900 mm). Individual high chairs may be used to support the bars in the top of concrete bridge decks in lieu of continuous high chairs. If individual high chairs are used, they shall be spaced at a maximum of 2 ft (600 mm) by 3 ft (900 mm) centers, or equivalent. The requirements, as herein specified, for supporting bars in concrete bridge decks are minimum requirements only and the Contractor is in no way relieved of the responsibility of providing additional supports as may be required to support the bars firmly in their correct position. When working loads on the bars prior to and during concrete placement includes chutes, pipes, or tubes for pumping concrete, or other unusual material or equipment, special consideration shall be given to the need for supplementary bar supports.

In addition to the requirements for tying bars at intersections, as herein specified, the bars in the tops of slabs shall be securely held in place by No. 9 (3.8 mm) wire ties, or other devices fastened to the structural steel, falsework, or other structural component at a maximum of 25 ft (7.6 m) longitudinal and 15 ft (4.5 m) transverse spaces. Welding to the structural steel will not be permitted.

Epoxy coated reinforcement bars shall be tied with plastic or epoxy coated wires or acceptable molded plastic clips. After the bars are in place and before placement of the concrete, the coated bars will be inspected for damage to the coating. Patching and repair of damaged epoxy coated reinforcement shall be according to Article 508.04. Damage caused during shipment of epoxy bars or by installation procedures or both need not be repaired in cases where the damaged area is $1/4 \times 1/4$ in. (6 x 6 mm) or smaller, and the sum of all damaged areas in each 1 ft (300 mm) length of bar does not exceed two percent of the bar surface area. All damaged areas larger than $1/16$ sq in. (40 sq mm) shall be repaired and all bars with total damage greater than two percent of bar surface area in any 1 ft (300 mm) length of

bar shall be rejected and removed. The total bar surface area covered by patching material shall not exceed five percent. Epoxy-coated bars at bonded deck construction joints shall be protected from coating damage during preparation of the joint surfacing for bonding. If sandblasting is used in preparation of the joint area, as allowed in Article 503.09(b), the Contractor shall be required to wrap or otherwise protect the bar coating during the blasting operation.

Prior to the placement of concrete for bridge decks, the clearance for the top mat of reinforcement bars shall be checked. A template shall be attached to the finishing machine or vibrating screed and a dry run shall be made over the entire area of the deck. The template shall be set to 1/4 in. (6 mm) less than the specified clearance to allow for tie wires. Any reinforcement exceeding the allowable tolerance shall be corrected before the start of concrete placement.

508.06 Splicing. Reinforcement bars shall be furnished in their full lengths and splicing will only be permitted where shown on the plans or by written approval of the Engineer. All splicing shall be performed as specified herein; splicing by welding will not be allowed.

(a) Lap Splicing. Lap Splicing shall be performed as follows.

- (1) Contact Lap Splice. Bars to be spliced along a continuous line of reinforcement shall be lapped the specified length, placed in direct contact, and wired together.
- (2) Non-Contact Lap Splice. Bars to be spliced, which are not along a continuous line of reinforcement and not specified to be contact spliced, shall be lapped the specified length and either spaced transversely a clear distance apart or contact spliced as described in (1) above, whichever requires the least adjustment to the bar spacing. The clear distance apart shall be from a minimum of 2 1/2 in. (65 mm) to a maximum of either 1/5 the lap length or 6 in. (150 mm), whichever is least.

(b) Bar Splicer Assemblies. When specified on the plans, the splicing of bars shall be performed with bar splicer assemblies. The assemblies shall be of an approved type and shall develop, in tension, at least 125 percent of the yield strength of the lapped reinforcement bars.

When both reinforcement bars being spliced are epoxy coated, the bar splicer assembly shall also be epoxy coated according to AASHTO M 284.

(c) Mechanical Splicers. The mechanical splice connection shall be made by means of a mechanical splicer. Splicer bar type systems lapped with the primary reinforcement will not be allowed. The mechanical splicer shall be of an approved type and shall develop, in tension, at least 125 percent of the specified yield strength of the bars to be spliced.

When both reinforcement bars to be spliced are epoxy coated, the mechanical splicer shall also be epoxy coated according to AASHTO M 284.

The Contractor shall supply the manufacturer's installation instructions to the Engineer prior to installing the mechanical splicers.

508.07 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Reinforcement bars and epoxy coated reinforcement bars incorporated in special reinforced pavement designs and in structures will be measured in pounds (kilograms) as computed for the sizes and lengths of bars shown on the plans or authorized by the Engineer. In computing the quantity to be paid for, the quantity of the bars of the cross section shown on the plans, or authorized, will be used. These weights (masses) are given in the following table.

Bar Size (English)	Weight, lb/ft
No. 3	0.376
No. 4	0.668
No. 5	1.043
No. 6	1.502
No. 7	2.044
No. 8	2.670
No. 9	3.400
No. 10	4.303
No. 11	5.313
No. 14	7.650
No. 18	13.600

Bar Size (metric)	Mass, kg/m
No. 10	0.560
No. 13	0.994
No. 16	1.552
No. 19	2.235
No. 22	3.042
No. 25	3.973
No. 29	5.060
No. 32	6.404
No. 36	7.907
No. 43	11.380
No. 57	20.240

The computed weight (mass) will not include the extra metal used when bars larger than those specified are substituted by the Contractor with the permission of the Engineer, the extra metal necessary for splices when bars shorter than those specified are substituted with the permission of the Engineer, the weight (mass) of any devices used to support or fasten the steel in correct position, the weight (mass) of the epoxy coating, or the weight (mass) of specified test bars.

Tie bars in pavement or between pavement and other new and/or existing portland cement concrete appurtenances, including all labor and materials required for installation and testing, will not be paid for separately, but shall be considered as included in the unit bid price for the portland cement concrete item involved. Dowel bars in load transmission devices for pavement, and marginal bars in pavement, when required, will not be measured for payment. Reinforcement bars required for concrete piles or other reinforced concrete work in structures, where the concrete is not measured for payment in cubic yards (cubic meters), will not be measured for payment, but shall be considered as part of the piles or other complete units that are to be paid for as such. If the weight (mass) of the reinforcement per unit of measurement is increased from that shown on the plans, by authority of the Engineer, the additional weight (mass) of the steel will be measured for payment.

508.08 Basis of Payment. Reinforcement bars in special reinforced pavement designs and in reinforced concrete structures where the concrete is paid for at a unit price per cubic yard (cubic meter), will be paid for at the contract unit price per pound (kilogram) for REINFORCEMENT BARS or REINFORCEMENT BARS, EPOXY COATED.

Bar splicer assemblies will be paid for at the contract unit price per each for BAR SPLICERS.

Mechanical splicers will be paid for at the contract unit price per each for MECHANICAL SPLICERS.

SECTION 509. METAL RAILINGS

509.01 Description. This work shall consist of furnishing and erecting metal railings, and furnishing, erecting, maintaining, and removing temporary steel railings.

509.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Structural Steel	1006.04
(b) Structural Steel Coatings	1008
(c) Steel Pipe	1006.18
(d) Aluminum for Railings	1006.30
(e) Stainless Steel Hardware	1006.31
(f) Fabric Reinforced Elastomeric	1028
(g) Steel Posts for Railings	1006.34(a)
(h) Tubular Steel Rail for Railings	1006.34(b)
(i) Steel Shapes and Plates for Railing	1006.34(c)
(j) High-Strength Steel Bolts, Nuts, and Washers	1006.08(b)
(k) Malleable Castings	1006.16
(l) Chemical Adhesive Resin System	1027.01
(m) Hardware for Railings	1006.29(d)
(n) Threaded Anchor Rods	1006.09
(o) Chain Link Fabric (Note 1)	1006.27
(p) Nonshrink Grout	1024.02

Note 1. When galvanized fencing is specified, the chain link fabric shall be according to Article 1006.27(a)(1)a., b., or c. When painting is specified for posts and/or frames, the chain link fabric, ties and tensioning components shall be vinyl coated according to Article 1006.27(a)(1)d.

CONSTRUCTION REQUIREMENTS

509.03 General. Work shall be according to the details shown on the plans, and lines and grades shall not follow any defects in the structure. When the structure is on a grade, rail posts shall be vertical, except posts for metal railings on concrete parapets and welded frames carrying chain link fencing shall be normal to the theoretical grade. Top of railings shall be parallel to grade line. High spots shall be ground and low spots shimmed.

All welds facing pedestrian areas shall be ground smooth in the shop. The rails shall be straight and true to line, without kinks, bends, or warps, and straightened as necessary before shipment.

509.04 Shop Drawings. Before beginning fabrication, the Contractor shall submit shop drawings to the Engineer according to Article 505.03. For railings constructed according to standard Department details, the drawings will not be formally reviewed, but will be included in the project record. When special non-standard details are required by the plans or proposed by the Contractor, the drawings shall be submitted for approval.

509.05 Steel Railings. Fabrication, inspection, storage, and erection of steel railings shall be according to Section 505, except that galvanized railing and accessories shall be stored according to Article 1006.34(d).

- (a) Type T-1, TP-1, S-1, SM, WT, and Type 2399 Steel Railings. For top mounted posts, three galvanized or ASTM A 304 stainless steel shims per post, one at 1/8 in. (3 mm) and two at 1/16 in. (2 mm), shall be provided for 25 percent of the posts. Shims shall be similar to base plate in size and holes.

For side mounted posts, a 1/8 in. (3 mm) thick fabric reinforced elastomeric pad shall be placed between the post and the concrete.

For side mounted rails on multi-span bridges, sufficient galvanized steel shims shall be provided to align rails between adjacent spans. Various thicknesses may be used, with no more than three shims per post.

The 3/4 in. (M20) diameter high strength bolts used to connect the angles to the post shall be tightened according to Article 505.04(f)(2). The 1 in. (M24) diameter high strength bolts connecting steel to the concrete shall be brought to a snug tight condition and given an additional 1/8 turn. The 5/8 in. (M16) cap screws in the bottom of the posts shall be brought to a snug tight condition only.

- (b) Tubular Thrie Beam Retrofit Rail. In addition to the requirements of Article 509.04, the tubular thrie beam rail section shall be fabricated by welding two thrie beam rail elements according to the details shown on the plans. The thrie beam rail section shall be according to the requirements of AASHTO M 180, Type 1, of the class specified.

All structural steel shapes and plates shall be galvanized.

Posts shall be attached to the concrete by drilling and setting anchor rods according to Article 509.06.

The standard length for a tubular thrie beam section is 25 ft 0 in. (7.5 m). Posts shall be provided at standard 8 ft 4 in. (2.5 m) centers whenever practical.

Posts shall not be located closer than 1 ft 3 in. (375 mm) to an existing bridge expansion joint or end of bridge.

In the event that standard lengths of tubular thrie beam cannot be longitudinally positioned to meet the requirements, shorter custom fabricated section(s) will be specified with a minimum length of 2 ft 6 in. (750 mm) and hole spacing for joints the same as full length sections.

All splice bolts shall be 5/8 in. (M16) diameter, unless otherwise noted.

Tubular thrie beam expansion joint shall be provided between any two posts which span a bridge expansion joint. Bolts located at expansion joints shall be provided with locknuts or double nuts and shall not be tightened beyond a point that prevents thermal expansion and contraction of the rail.

The expansion joint width shall be 2 1/2 in. (65 mm) at 50 °F (10 °C) and shall be adjusted for other temperatures according to the requirements of Article 520.04.

- (c) Pedestrian Railings, Bicycle Railings, and Bridge Fence Railings. The furnishing and installing of the chain link fabric, when specified, shall be according to Section 664. Stretcher bars shall be used on all four sides of each panel. The chain link fabric shall be placed along the pedestrian side as detailed on the plans. The maximum post spacing shall be 10 feet (3 m).

At the Contractor option, either cast in place anchor devices or drilled and set anchor rods may be used to attach the posts to the concrete. Drilling and setting of anchor rods shall be according to Article 509.06.

- (d) Pipe Handrail. The railings shall be standard (Schedule 40) pipe and the posts shall be extra strong (Schedule 80) pipe. Either welded or seamless pipe may be used. Rail panel lengths shall not exceed 7 ft (2.1 m) center-to-center of posts for 1 1/2 in. (40 mm) pipe and 8 ft (2.4 m) for larger diameter pipe. No railing shall be continuous for more than 40 ft (12 m) without expansion joints. Provision for expansion shall also be made in any panel crossing an expansion joint in the structure.

Connection of railings to posts shall be by the use of fittings or welding. One type of connection shall be used for railings throughout a structure. Welded joints shall be continuous, and weld surfaces shall be ground smooth. The use of couplings or unions will not be permitted.

When connections are made with fittings, rails shall be continuous through fittings at intermediate posts where expansion is not provided, and pinned, or welded to the fittings. Rails shall be threaded or welded into fittings at end and corner posts and shall have slip connections at points where expansion is provided.

The pipe handrail shall be fastened to the concrete or other support by means of standard flange plates with four anchors each. Anchors for this purpose shall have a diameter of not less than 5/8 in. (16 mm).

Whenever practicable, anchors shall be cast-in-place bolts, otherwise, they shall be anchor rods drilled and set according to Article 509.06.

When painted rail is specified, the cleaning and painting shall be according to Section 506, using the paint system specified for structural steel.

When galvanizing is specified, all posts, rails, splices, anchorage devices and plates shall be galvanized according to AASHTO M 111. Vent holes for galvanizing shall be placed in the posts and rails at locations that will not allow the accumulation of moisture in the members. Field drilled holes shall be spot painted with one coat of aluminum epoxy mastic paint before erection. All bolts, nuts, and anchors shall be galvanized according to AASHTO M 232, except stainless steel hardware shall be uncoated.

509.06 Setting Anchor Rods. Drilled holes in concrete for anchor rods shall be to the diameter and depth required by the adhesive manufacturer for the size and type of anchor rod specified. The anchor rods shall be set with capsule or cartridge type adhesive systems that have been previously tested and approved by the Department. The sealed capsule or cartridge shall contain pre-measured amounts of adhesive chemicals and be installed according to the manufacturer's written instructions.

509.07 Temporary Steel Railing. The 1 in. (M24) diameter high strength bolts or threaded anchor rods used to connect the posts to the deck shall be tightened according to Article 505.04(f)(2), except the nut shall only be rotated 1/8 turn beyond snug tight.

When required or allowed by the Engineer anchor rods may be drilled and set according to Article 509.06.

Contact surfaces between the post flange, rail, and inside face of the brackets for the alternate rail connection detail shall be free of all lubricants. The nuts for 5/8 in. (M16) high strength studs used to connect the bracket to the post shall be tightened to snug tight and given an additional 1/8 turn.

After the removal of bolts and anchorage devices, all holes in the permanent deck shall be filled flush with the deck surface using a nonshrink grout. Anchors |

drilled and set in a permanent deck shall be cut flush with the deck surface after removal of the temporary steel railing.

509.08 Aluminum Railings. During manufacture, transport, and erection, railing shall be protected from scratching, denting or other defects that may affect its durability or appearance.

Rail elements shall be extruded in modular lengths of 30 ft (9 m), except for end/terminal sections, over expansion joints, or sections curved to a radius of 2300 ft (700 m) or less. Each rail element shall be attached to no less than two posts. All joints in rails shall be spliced as detailed.

Three aluminum shims per post, one at 1/8 in. (3 mm) and two at 1/16 in. (2 mm), shall be provided for 25 percent of the posts. Shims shall be similar to base plate in size and holes.

509.09 Method of Measurement. This work will be measured for payment in place in feet (meters). The length measured will be the overall length along the top longitudinal railing member through all posts and gaps.

509.10 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for STEEL RAILING, or ALUMINUM RAILING, of the type specified; STEEL RAILING (TEMPORARY); TUBULAR THRIE BEAM RETROFIT RAIL FOR BRIDGES; PEDESTRIAN RAILING; BICYCLE RAILING; BRIDGE FENCE RAILING; BRIDGE FENCE RAILING (SIDEWALK); PARAPET RAILING; and PIPE HANDRAIL.

SECTION 510. RESERVED

SECTION 511. SLOPE WALL

511.01 Description. This work shall consist of constructing a slope wall on a prepared earth bed.

511.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Fabric Reinforcement	1006.10

511.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Membrane Curing Equipment	1101.09

CONSTRUCTION REQUIREMENTS

511.04 General. This work shall consist of the preparation of the earth bed, excavation, backfilling, disposal of surplus material according to Section 502, and the construction of concrete slope walls according to Section 503. Preferably, the slope

wall shall be constructed in alternate sections each approximately 9 ft (2.7 m) in width.

The fabric reinforcement shall be supported 2 in. (50 mm) below the upper surface of the slope wall by concrete blocks. A clear distance of 2 in. (50 mm) shall be maintained between the fabric reinforcement and the outside face of any vertical or inclined toe or cutoff wall. The fabric reinforcement shall be continuous across all construction joints and shall extend into each section a minimum of 6 in. (150 mm) from any adjacent previously placed section. Adjacent sections of fabric reinforcement shall be lapped a minimum of 6 in. (150 mm) in all cases.

511.05 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements of the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. This work will be measured for payment in place and the area computed in square yards (square meters). In computing the quantity for payment, the dimensions used will be those established by the Engineer to conform to the elevations of the natural ground line or stream bed. The area for measurement will include the upper, sloped surface of the wall. Anchor and cut-off walls will not be measured for payment.

511.06 Basis of Payment. This work will be paid for at the contract unit price per square yard (square meter) for SLOPE WALL of the thickness specified.

SECTION 512. PILING

512.01 Description. This work shall consist of furnishing and driving piles.

512.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Timber Piling	1007.08
(b) Preservative Treatment	1007.12
(c) Portland Cement Concrete	1020
(d) Reinforcement Bars and Fabric	1006.10
(e) Structural Steel	1006.04
(f) Structural Steel Coatings	1008
(g) Metal Shell Piling	1006.05(a)
(h) Steel Piling	1006.05(b)
(i) Pile Shoes	1006.05(e)
(j) Fastenings for Timber Structures	1006.17
(k) Precast Concrete Products	1042

CONSTRUCTION REQUIREMENTS

512.03 Precast Concrete and Precast, Prestressed Concrete Piles.

Precast concrete piles shall be manufactured according to Section 1042 and precast, prestressed concrete piles shall be manufactured according to the Department's "Manual for Fabrication of Precast, Prestressed Concrete Products" in effect on the date of invitation for bids.

- (a) Splicing. Splicing of precast concrete or precast, prestressed concrete piles for the purpose of driving additional length will not be allowed.
- (b) Extensions. Extensions on precast concrete or precast, prestressed concrete piles shall be avoided; but when necessary, they shall be made as shown on the plans.
- (c) Reinforcement. Construction requirements for reinforcement bars shall be according to Section 508.

512.04 Metal Shell Piles. Metal shell piles shall consist of a steel shell which is driven into place and filled with concrete. The walls of all shells shall be of sufficient thickness, but not less than the minimum specified, to permit driving without distortion or damage.

- (a) Splicing. Splicing of metal shell piles shall be as follows.
 - (1) Planned Splices. Planned field or shop splices may be used when allowed per Article 512.10 or when the lengths specified in Article 512.16 exceed the estimated lengths specified in the contract plans by at least 10 ft (3 m). The location of planned splices shall be approved by the Engineer and located to minimize the chance they will occur within the 10 ft (3 m) below the base of the footing, abutment, or pier.
 - (2) Unplanned Splices. Unplanned field splices shall be used as required to furnish lengths beyond those specified in Article 512.16. The length of additional segments shall be specified by the Engineer.

All splices shall be accomplished by a complete joint penetration (CJP) weld or a commercial drive splice with Department approved commercial splicer welding detail. Welder qualification and certification will be required for all splicing according to Article 512.07.

- (b) Driving. Whenever practicable, all piles for any one bent, pier, or abutment shall be completely driven before any concrete is placed in the shells. If this is impracticable, driving of additional piles within 15 ft (4.5 m) shall be deferred until the concrete in all shells within this zone has been in place for at least 24 hours from the time placing is completed.
- (c) Inspection. The Contractor shall have a suitable light available at all times for illuminating the entire interior length of the shells. Driven shells shall be watertight and free of bends, kinks, or other deformations that would impair the strength or efficiency of the completed pile.

If the shells are not filled with concrete shortly after being driven, the tops of the shells shall be temporarily sealed.

- (d) **Reinforcement.** Construction requirements for reinforcement bars shall be according to Section 508. Reinforcement shall be used inside the shells as shown on the plans. Reinforcement shall be rigidly fastened together and lowered into the shell before the concrete is placed. Spurs or spacers shall be used to ensure the specified clearance for the bars.
- (e) **Filling.** Prior to filling with concrete, the metal shells shall be again inspected. Any water or foreign substances found within shall be removed. During filling, the top 10 ft (3 m) of concrete in the piles shall be consolidated by internal vibration.

512.05 Steel Piles. Steel piles shall consist of structural steel shapes such as H-piles or other sections indicated on the plans.

- (a) **Splicing.** Splicing of steel piles shall be as follows.
 - (1) **Planned Splices.** Planned field or shop splices may be used when allowed per Article 512.10 or when the lengths specified in Article 512.16 exceed the estimated lengths specified in the contract plans by at least 10 ft (3 m). The location of planned splices shall be approved by the Engineer and located to minimize the chance they will occur within the 10 ft (3 m) below the base of the footing, abutment, or pier.
 - (2) **Unplanned Splices.** Unplanned field splices shall be used as required to furnish lengths beyond those specified in Article 512.16. The length of additional segments shall be specified by the Engineer.

All splices shall be accomplished by a complete joint penetration (CJP) weld of the entire cross-section, or by the Department's standard steel pile field splice, or by the use of a commercial splicer with a Department approved commercial splicer welding detail. Welder qualification and certification will be required for all splices according to Article 512.07.

- (b) **Painting and Field Connections for Trestle Bents.** Before being driven or placed, all steel piles, caps, splices, and bracing members in trestle bents shall be shop painted with inorganic zinc-rich primer. When specified, after the piles are driven and all bracing members, concrete caps, and encasement are in place, all exposed steel shall be given one complete coat of field paint. All painting shall be according to Section 506.

When piles are not driven sufficiently exact to line up with bracing members, fills or shims shall be furnished and placed to secure proper attachment of the bracing.

- (c) **Pile Shoes.** When specified, steel piles shall be fitted with pile shoes. The pile shoes shall be fastened to the piles using a 5/16 in. (8 mm) continuous fillet weld along the flange contact areas.

512.06 Timber Piles. Full length piles shall be used and no planned splices will be allowed. When unplanned splices are required to furnish lengths beyond those specified in Article 512.16, they shall be of the butt joint type and the added piece shall conform closely in diameter to the main pile at the point of splice. The pile shall be sawed square and the butt joints shall bear evenly over the entire surface. The splices shall be made by the use of at least four steel plates or a metal pipe sleeve. The plates shall be at least 4 ft (1.2 m) long, 3 1/2 in. (90 mm) wide and 3/8 in. (10 mm) thick and each plate shall be bolted to the pile with not less than two 3/4 in. (M20) bolts both above and below the joint. Pipe sleeves shall be standard steel pipe, at least 3 ft (900 mm) long and shall be fastened with not less than three 5/8 in. (M16) lag screws, 5 in. (125 mm) long, both above and below the joint. All metal used for splicing piles shall be galvanized according to Article 1006.17.

Before the splice is assembled, if the joint is to be above low ground water line, all sawed surfaces and holes in piles shall be treated according to Article 1007.13.

512.07 Welding. Welding shall be according to the applicable requirements of Article 505.04(q), except for the following.

Welders shall be qualified according to either AWS D1.1 or D1.5 Code, except the macroetch specimen requirement of the "Qualification Test for Fillet Welds Only (Option 1)" will be waived. Welding procedures are considered prequalified if consumables in Table 4.1 of the D1.5 BWC and low hydrogen practices of Section 4 in the BWC are employed. Submittal of weld procedure specifications (WPSs) for the Engineer's approval is not required, but the welder must have written WPSs for the procedures employed, showing consumables, variables (amps, volts, etc.), joint configuration, surface preparation, and preheat. Submerged arc welding (SAW) is not mandatory for CJP welds in flanges and/or webs of steel piles. Non-destructive testing of pile splices by the Contractor will not be required unless visual inspection by the Engineer indicates significant anomalies.

512.08 Storage and Handling of Piles. The method of storing and handling piles shall protect them from damage.

- (a) Treated Timber Piles. Treated timber piles shall be stored at the site of the work according to Article 1007.13 and handled according to Articles 507.05 and 1007.13.
- (b) Precast Concrete and Precast, Prestressed Concrete Piles. Precast concrete piles shall be lifted by suitable devices attached to the pile at not less than two points for piles up to 45 ft (14 m) long, and not less than three points for piles over 45 ft (14 m) long. Precast, prestressed concrete piles shall be lifted by suitable devices and supported during storage or transportation at not less than two points for piles up to 65 ft (20 m) long and not less than three points for piles over 65 ft (20 m) long. The locations of the points of support shall be as shown on the precast shop plans.

The piles shall be lifted by a bridle attached to the pile or special embedded or attached lifting devices. Unless special lifting devices are attached for lifting, the pickup points shall be plainly marked on all piles before removal from the casting bed and all lifting shall be done at these points. The

method of handling precast concrete piles shall not induce stresses in the reinforcement in excess of 12,000 psi (83,000 kPa), using a factor of safety of two to account for impact and shock. The method of handling precast prestressed concrete piles shall not induce tensile stresses in the concrete in excess of 210 psi (1400 kPa), using a factor of safety of two to account for impact and shock.

- (c) Steel Piles. The handling and storing of steel piles shall be according to Article 505.08(c).
- (d) Metal Shell Piles. Metal shell piles shall be stored off the ground with sufficient cribbing to prevent bending or distortion of the pile and to prevent dirt, water, or other foreign material from entering the metal shell.

512.09 Preparation for Driving. Piles shall not be driven until after the excavation or embankment near piles for the footings, abutments, piers, or channel construction is completed. Any material forced up between the piles shall be removed to the correct elevation before concrete in the foundation is placed.

- (a) Pointing Timber Piles. When shown on the plans, the piles shall be shod with metal shoes of a design satisfactory to the Engineer. The points of the piles shall be shaped to secure an even and uniform bearing on the shoes.
- (b) Precast and Precast, Prestressed Concrete Piles. All piles shall be saturated with water, for the entire length of the pile, at least six hours prior to driving.
- (c) Precoring Through Embankment or Dense Soils. When shown on the plans, holes as detailed shall be precored for piles which are to be driven through new embankment or dense soils. If oversize holes are drilled, the void space outside of the pile shall be filled with dry, loose sand.

512.10 Driving Equipment. The equipment for driving piles shall be adequate for driving piles at least 10 ft (3 m) longer than the longest estimated pile length specified in the contract plans without splicing, unless the estimated pile length exceeds 55 ft (17 m) or prevented by vertical clearance restrictions. The use of shorter length equipment or the use of preplanned splices (necessitated by estimated pile lengths exceeding 55 ft (17 m) or vertical clearance restrictions) shall meet the approval of the Engineer. The equipment for driving piles shall be according to the following.

- (a) Hammers. Piles shall be driven with an impact hammer such as drop, steam/air, hydraulic, or diesel. The driving system selected by the Contractor shall not result in damage to the pile. The impact hammer shall be capable of being operated at an energy which will maintain a pile penetration rate between 1 and 10 blows per 1 in. (25 mm) when the nominal driven bearing of the pile approaches the nominal required bearing.

For hammer selection purposes, the minimum and maximum hammer energy necessary to achieve these penetrations may be estimated as follows.

$$E \geq \frac{32.90 R_N}{F_{eff}} \quad (\text{English})$$

$$E \leq \frac{65.80 R_N}{F_{eff}} \quad (\text{English})$$

$$E \geq \frac{10.00 R_N}{F_{eff}} \quad (\text{metric})$$

$$E \leq \frac{20.00 R_N}{F_{eff}} \quad (\text{metric})$$

Where:

R_N = Nominal required bearing in kips (kN)

E = Energy developed by the hammer per blow in ft lb (J)

F_{eff} = Hammer efficiency factor according to Article 512.14

When steel piles are driven to hard rock, the penetration resistance and hammer energy may both abruptly increase, making it difficult to calculate the penetration rate and increase concern for pile tip damage. Under these conditions, the Contractor shall reduce hammer energy and/or calculate the penetration rate over a reduced penetration increment (less than 1 in. (25 mm)) to assure that the pile has obtained the nominal required bearing and has not sustained damage.

Air/Steam hammers may be single or double acting but must have a total weight of striking parts of not less than one-third of the weight (mass) of the pile and drive cap and in no case shall the striking part have a weight (mass) less than 1.4 tons (1.3 metric tons). The equipment supplied with the hammer shall maintain the pressure at the hammer that is specified by the manufacturer. The Contractor shall provide the Engineer with the hammer specifications so that the energy developed by the hammer with each blow may be determined.

Diesel hammers may be open-ended or closed-ended. Open-end single acting diesel hammers shall be equipped with either a device to measure ram impact velocity or speed of operation (with the necessary correlation charts) unless the stroke height can be directly observed to determine the energy developed by the hammer with each blow. Closed-end double acting diesel hammers shall be equipped with a bounce chamber pressure gauge that is easily readable and the Contractor shall provide a correlation chart and hammer data to determine the energy developed by the hammer with each blow.

Drop hammers shall not be used for driving precast piles or piles with a nominal required bearing exceeding 60 tons (533 kN). The hammer data shall be provided to the Engineer and the minimum ram weight (mass) of the hammer ram is 1 ton (0.9 metric tons). The fall of the ram shall be regulated

so as to avoid injury to the piles, but shall in no case exceed 15 ft (4.6 m). In no case shall the ram weight (mass) be less than the combined weight (mass) of the pile and drive cap.

Hydraulic hammers shall be equipped with an energy readout device and the Contractor shall furnish wave equation analysis to aid in the determination of the adequacy of the hammer and indicate the nominal driven bearing of the pile. The formula provided in Article 512.14 may not be used for these calculations.

Vibratory hammers may only be used to install piles when approved by the Engineer. Piles installed with vibratory hammers shall be further driven with an impact hammer until the nominal driven bearing is verified to be equal to or greater than the nominal required bearing.

- (b) Drive Heads. The heads of all piles shall be protected by a pile drive head also referred to as a helmet or cap during driving. The drive head shall consist of a cast or structural steel helmet capable of holding the axis of the pile in line with the axis of the hammer.

The heads of metal shell piles shall be protected by a combination driving head and pilot capable of distributing the hammer blow uniformly across the metal shell cross section and maintaining the alignment of the pile.

- (c) Hammer and Pile Cushions. The heads of timber, precast concrete, and precast, prestressed concrete piles shall be protected by a pile cushion between the pile and driving head during driving to prevent damage to the pile. The minimum pile cushion thickness prior to driving shall be 3 in. (75 mm). A new cushion shall be provided if, during driving, the cushion is either compressed to less than 60 percent of the original thickness or it begins to burn. Hammers which require a hammer cushion shall be inspected prior to driving and after each 50 hours of operation thereafter. The hammer cushion shall be replaced when there is a reduction in thickness exceeding 25 percent; or for air/steam hammers, when the reduction in thickness exceeds the manufacturer's limitations.
- (d) Leads. Pile leads shall be used to maintain the alignment of the pile and hammer to assure concentric impact for each blow. Swinging leads shall be set or toed in the ground prior to the start of driving. The design of the leads shall accommodate the length of pile segments, the hammer, and other required equipment, and shall be capable of maintaining the alignment of the pile during driving within the tolerances specified.
- (e) Followers. The driving of piles with followers shall be done only with the written permission of the Engineer. Followers shall be fabricated to bear evenly and concentrically on the pile as well as maintain proper alignment with the pile to efficiently deliver the energy from the hammer to the pile. The first pile in every group of ten shall be driven without a follower, by using a longer pile if necessary, and shall be used, to determine the average nominal driven bearing of the other piles in the group.

- (f) Jets. Water and air jets may be used when approved by the Engineer. The jets shall have the capacity to erode the material adjacent to the pile without causing damage to the site or affecting vertical or lateral capacity of adjacent piles. After the use of jets has been discontinued within the substructure area, the piles shall be further driven with an impact hammer until the nominal driven bearing is verified to be equal to or greater than the nominal required bearing.

512.11 Penetration of Piles. Piles shall be installed to a penetration that satisfies all of the following.

- (a) The nominal driven bearing, as determined by the formula in Article 512.14, is not less than the nominal required bearing shown on the plans.
- (b) The pile tip elevation is at or below the minimum tip elevation shown on the plans. In cases where no minimum tip elevation is provided, the piles shall be driven to a penetration of at least 10 ft (3 m) below the bottom of footing or below undisturbed earth, whichever is greater.

Except as required to satisfy the minimum tip elevations required in 512.11(b) above, piles are not required to be driven more than one additional foot (300 mm) after the nominal driven bearing equals or exceeds the nominal required bearing; more than three additional inches (75 mm) after the nominal driven bearing exceeds 110 percent of the nominal required bearing; or more than one additional inch (25 mm) after the nominal driven bearing exceeds 150 percent of the nominal required bearing. When piles fail to achieve nominal driven bearings in excess of the nominal required bearing after driving the full furnished lengths, but are within 85 percent of nominal required bearing, these piles shall be left for a minimum of 24 hours to allow for soil setup and retesting before splicing and driving additional length. After the waiting period has passed, the pile shall be redriven to check the gain in nominal driven bearing upon soil setup. The soil setup nominal driven bearing shall be based on the number of redriving blows necessary to drive the pile an additional 3 in. (75 mm) using a hammer that has been warmed up by applying at least 20 blows to another pile. These piles will be accepted if they exhibit a nominal driven bearing larger than nominal required bearing.

512.12 Tolerances in Driving. Piles shall be driven with a variation from the vertical or required batter alignment of not more than 1/4 in./ft (20 mm/m). Piles shall be driven to an accuracy where no portion of the visible pile is out of plan position by more than 6 in. (150 mm) in any direction, provided that no design modification is required to accommodate the pile location, and where forcing them into tolerance after driving would not result in injury to the piles.

512.13 Cutoffs. After driving piles, they shall be cut off perpendicular to their longitudinal axis at the elevations shown on the plans. The remaining portion of the piles shall be free of damage or bruising. All debris shall be removed and disposed of from around the piles.

The heads of all treated timber piles, when not encased in concrete, shall be field treated after cutoff according to Article 1007.13. Each pile head shall then be covered with a sheet of galvanized steel, not lighter than 24 gauge (0.701 mm) and of sufficient area to project at least 4 in. (100 mm) outside the pile at any point, which

shall be bent down over the pile to fit neatly and exclude water in the best possible manner. The edges shall be trimmed neatly and fastened to the pile face with large headed galvanized roofing nails.

The cutoff portions of all piles, including test piles, shall be retained and made available for use in splicing or extending piles, if required, until the pile driving is complete. Upon completion of the work, the cutoffs shall become the property of the Contractor and shall be disposed of.

512.14 Determination of Nominal Driven Bearing. The nominal driven bearing of each pile will be determined by the WSDOT formula as follows.

$$R_{NDB} = \frac{6.6 F_{eff} E \ln (10N_b)}{1000} \quad (\text{English})$$

$$R_{NDB} = \frac{21.7 F_{eff} E \ln (10N_b)}{1000} \quad (\text{metric})$$

Where:

R_{NDB} = Nominal driven bearing of the pile in kips (kN)

N_b = Number of hammer blows per inch (25 mm) of pile penetration

E = Energy developed by the hammer per blow in ft lb (J)

F_{eff} = Hammer efficiency factor taken as:

0.55 for air/steam hammers

0.47 for open-ended diesel hammers and steel piles or metal shell piles

0.37 for open-ended diesel hammers and concrete or timber piles

0.35 for closed-ended diesel hammers

0.28 for drop hammers

For piles driven on a batter, the value of "E" will be multiplied by the hammer energy reduction coefficient, "U" will be determined as follows.

$$U = \frac{0.25 (4 - m)}{(1 + m^2)^{0.5}} \quad \text{for drop hammers}$$

$$U = \frac{0.1 (10 - m)}{(1 + m^2)^{0.5}} \quad \text{for all other hammers}$$

Where:

U = Hammer energy reduction coefficient, less than unity

m = Tangent of the angle of batter (i.e. $m = .25 = 3/12$ for 3H:12V batter)

The Engineer will determine the value of "E". For drop, single acting air/steam hammers, and open type diesel hammers, the kinetic energy will be used by measuring ram velocity. When measuring ram velocity is not possible, it may be approximated by the potential energy calculated by multiplying the weight (mass) of hammer striking parts by the observed fall or stroke height. For double acting air/steam hammers and closed type diesel hammers, the energy will be calculated by using ram weight (mass) and bounce chamber pressure. The Contractor shall submit hammer literature and correlation charts to aid in determining hammer energy of each blow. In either case, the calculated value of "E" will be further reduced by the hammer energy reduction coefficient "U" prior to being used in the formula to calculate " R_{NDB} " or " N_b ".

The preceding formula for piles driven with a drop hammer is applicable only when: the hammer has an unrestricted free fall; the pile head is not broomed, crushed or splintered; there is no appreciable bounce of the hammer after striking the pile; and the penetration is at a uniform or uniformly decreasing rate.

When specified in the contract or when a hydraulic hammer is used, the nominal driven bearing of the piles will be determined by the results of a wave equation analysis. The analysis will take into account the hammer driving system, site specific subsurface data, and project pile geometry to develop driving criteria which will not overstress the pile and correctly indicate its nominal driven bearing.

When specified in the contract, a static pile load test shall be performed on the specified piles of a group to determine their nominal driven bearing. The pile load test shall be performed according to ASTM D 1143. Shop drawings for the design of the load test frame shall be submitted to the Engineer.

512.15 Test Piles. Test piles shall be of the same material and size, satisfy all splicing requirements, and contain any pile shoes as specified for the production piles. Test piles shall be driven with the same equipment as will be used for driving the production piles. The furnished length for test piles shall be at least 10 ft (3 m) longer than the estimated length shown on the plans.

Before driving test piles, the excavation or embankment near piles shall be within 2 ft (600 mm) of the proposed grade of the footing, pier, abutment, or channel.

Test piles shall be driven to a nominal driven bearing ten percent greater than the nominal required bearing shown on the plans. The Engineer may stop the driving of any test pile at tip penetrations exceeding 10 ft (3 m) beyond the estimated length to check for pile setup according to Article 512.11. After any retesting, the Contractor shall recommence test pile driving, providing piling, splices, and any retests until the nominal driven bearing during driving reaches ten percent more than the nominal required bearing or the Engineer stops the driving due to having sufficient data to provide the itemized list of furnished lengths.

Test piles driven in production pile locations that are incorporated into the structure shall be cut off as permanent piles. Test piles not driven in a production location shall be cut off or pulled, as directed by the Engineer.

512.16 Length of Piles. The Contractor shall furnish pile lengths according to a written itemized list provided by the Engineer. Should the Contractor elect to

preorder piles prior to being provided with the itemized list, it shall be done at his/her own risk. The itemized list of furnished lengths will be based on the Engineer's evaluation of the test pile results, the soil boring data, and the estimated pile lengths on the plans. If the plans do not require a test pile, the itemized list of furnished lengths shall be as estimated on the plans. The length of test piles shall be according to Article 512.15.

512.17 Method of Measurement. Furnishing piles will be measured for payment in feet (meters). Measurement will include the total length of piles delivered to the site of the work, according to the itemized list furnished by the Engineer, and any additional lengths delivered for splicing as ordered by the Engineer. Measurements will be made to the nearest 0.1 ft (0.03 m).

Driving piles will be measured for payment in feet (meters). Measurement will include the total length of piles subtracting cutoffs. For precast concrete and precast, prestressed concrete piles, this length will not include extensions or the portion of the pile cutoff to make the extension. Measurements will be made to the nearest 0.1 ft (0.03 m).

512.18 Basis of Payment. This work will be paid for as follows.

- (a) **Furnishing Piles.** This work will be paid for at the contract unit price per foot (meter) for FURNISHING UNTREATED PILES and FURNISHING TREATED PILES, of the length specified; or FURNISHING PRECAST CONCRETE PILES, FURNISHING PRECAST PRESTRESSED CONCRETE PILES, FURNISHING METAL SHELL PILES, and FURNISHING STEEL PILES, of the size specified.
- (b) **Driving Piles.** This work will be paid for at the contract unit price per foot (meter) for DRIVING PILES.
- (c) **Extensions.** Extensions for precast concrete and precast, prestressed concrete piles will be paid for according to Article 109.04.
- (d) **Unplanned Splices.** Unplanned splices for metal shell, steel, and timber piles will be paid for according to Article 109.04.
- (e) **Test Piles.** Furnishing and driving test piles will be paid for at the contract unit price per each for TEST PILE, of the type specified. Driving test piles beyond the furnished test pile length will be paid for according to Article 109.04.
- (f) **Static Pile Load Tests.** This work will be paid for at the contract unit price per each for PILE LOAD TEST.
- (g) **Pile Shoes.** The furnishing and installing of pile shoes, including those for test piles driven in production locations, will be paid for at the contract unit price per each for PILE SHOES.
- (h) **Splices.** When the lengths specified in Article 512.16 exceed the estimated lengths specified in the contract plans by at least 10 ft (3 m), additional field

splices (for metal shell and steel piles) required to provide the lengths specified in Article 512.16 will be paid for according to Article 109.04.

- (i) Redriving of Piles. The redriving of piles to check for a gain in nominal driven bearing as specified in Article 512.11 will be paid for according to Article 109.04.

SECTION 513. TEMPORARY BRIDGES

513.01 Description. This work shall consist of the construction of temporary bridges, their maintenance in a safe condition for traffic, and their removal and disposal.

513.02 Design. If complete plans are not furnished by the Department, the details of design, materials to be used, sizes, spacing, and arrangement of members shall be determined by the Contractor. The highway loading, roadway width and overall length or waterway opening shall be as specified on the plans. The temporary bridge shall be designed according to the AASHTO Standard Specifications for Highway Bridges. Temporary bridge plans furnished by the Contractor shall be sealed by an Illinois licensed Structural Engineer.

513.03 Materials. All materials shall be according to Division 1000, except as modified herein. Used materials, except for anchor bolts, reinforcement bars, hardware for timber construction, and high strength bolts may be incorporated into the construction of temporary bridges provided those materials are in sound condition and suitable for the purpose intended. All materials shall meet the approval of the Engineer as to quality and suitability for the use intended.

The outer bark shall be removed from piles in temporary bridges at points where bracing or backing is attached; otherwise, the requirements of Article 1007.08(c) concerning the removal of bark shall not apply. Galvanizing of high strength bolts, anchor bolts, and hardware for timber construction will not be required. Epoxy coating for reinforcement bars for cast-in-place construction will not be required.

CONSTRUCTION REQUIREMENTS

513.04 Excavation and Backfill. Excavation and backfill shall be according to Section 502.

513.05 Piling and Timber. Except as modified herein, all work involving timber piles shall be according to the applicable portions of Sections 507 and 512. The requirements for treatment of piling, treatment of holes and pile tops, and metal coverings for piles shall not apply.

Timber construction shall be according to the applicable portions of Section 507. The requirements regarding the use of treated timber shall not apply. Timber shall be either rough or surfaced. Countersinking will not be required, except in the vertical roadway face of wheel guards and under longitudinal floor planks.

513.06 Other Construction. Cast-in-place concrete shall be according to Section 503. New precast concrete members shall be according to the applicable

portions of Section 504. The use of used precast concrete members shall be limited to the configuration and intent contemplated for the original design of the member. No cutting or splicing of used precast members will be allowed. The furnishing and erecting of structural steel shall be according to Section 505, except no painting of structural steel will be required. Reinforcement bars shall be according to Section 508. Metal railings shall be according to Section 509.

513.07 Maintenance. The Contractor shall maintain such temporary bridge in good condition. All labor and materials required for such maintenance, including the repair of any damage caused by traffic, shall be furnished by the Contractor.

513.08 Removal. After the need to maintain traffic on the temporary bridge has ceased to exist, it shall be removed and disposed of according to Article 501.04. No excavation or other material will be allowed to remain in the stream channel.

513.09 Method of Measurement. Rock excavation will be measured for payment according to Article 502.12.

513.10 Basis of Payment. This work will be paid for at the contract unit price per each for TEMPORARY BRIDGE COMPLETE.

Rock excavation will be paid for according to Article 502.13.

SECTION 514. RESERVED

SECTION 515. NAME PLATES

515.01 Description. This work shall consist of the furnishing and installing of name plates.

515.02 Materials. Name plates shall be made of brass, bronze, or other material as provided by the plans.

CONSTRUCTION REQUIREMENTS

515.03 General. The general features of design; the type, size, and spacing of letters and figures; the items of information to be shown on all name plates for structures constructed under a given contract; and the arrangement of these items shall be as shown on the plans. The surface of the name plate shall be polished.

515.04 Installation. Installation of name plates shall be as follows.

- (a) **Concrete Structures.** On concrete structures, the name plate shall be embedded in the concrete and fastened by means of four brass or bronze bolts with countersunk heads, or four lugs cast integral with the plate. The bolts or lugs shall project at least 3 in. (75 mm) into the concrete beyond the back of the plate.
- (b) **Steel Truss.** On steel truss spans, the plate shall be fastened on the steel member at the fabricating shop by brazing around the entire perimeter of the plate.

- (c) Steel Rails. On steel rails, the plate shall be bolted on with four, 3/8 x 1 in. (M10 x 25 mm) stainless steel or brass cap screws that are self tapping or drilled and tapped in the field.

515.05 Basis of Payment. This work will be paid for at the contract unit price per each for NAME PLATES.

SECTION 516. DRILLED SHAFTS

516.01 Description. This work shall consist of constructing drilled shaft foundations.

516.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete (Note 1)	1020
(b) Reinforcement Bars	1006.10
(c) Grout (Note 1) (Note 2)	1024.01
(d) Permanent Steel Casing	1006.05(d)

Note 1. When soil and ground water sulfate contaminates exceed 500 parts per million, a Type V cement will be required.

Note 2. The sand-cement grout mix shall be according to Section 1020 and shall be a 1:1 blend of sand and cement comprised of a Type I or II cement at 185 lb/cu yd (110 kg/cu m). The maximum water cement ratio shall be sufficient to provide a flowable mixture with a typical slump of 10 in. (250 mm).

516.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Concrete Equipment	1020.03
(b) Drilling Equipment (Note 1)	
(c) Hand Vibrator	1103.17(a)

Note 1. The drilling equipment shall have adequate capacity, including power, torque and down thrust, to create a shaft excavation of the maximum diameter specified to a depth of 20 percent beyond the depths shown on the plans.

516.04 Submittals. The following shall be submitted.

- (a) Qualifications. At the time of the preconstruction conference, the Contractor shall provide the following documentation.
 - (1) References. A list containing at least three projects completed within the three years prior to this project's bid date which the Contractor performing this work has installed drilled shafts of similar diameter, length, and site conditions to those shown in the plans. The list of

projects shall contain names and phone numbers of owner's representatives who can verify the Contractor's participation on those projects.

- (2) Experience. Name and experience record of the drilled shaft supervisor, responsible for all facets of the shaft installation, and the drill operator(s) who will be assigned to this project. The supervisor and operator(s) shall each have a minimum of three years experience in the construction of drilled shafts.
- (b) Installation Procedure. A detailed installation procedure shall be submitted to the Engineer for acceptance at least 45 days prior to drilled shaft construction and shall address each of the following items unless otherwise directed by the Engineer in writing.
- (1) Equipment List. List of proposed equipment to be used including cranes, drill rigs, augers, belling tools, casing, core barrels, bailing buckets, final cleaning equipment, slurry equipment, tremies, or concrete pumps, etc. Standby equipment shall be available to assure there is no delay in placing concrete once pouring operations have started.
 - (2) General Sequence. Details of the overall construction operation sequence, equipment access, and the sequence of individual shaft construction within each substructure bent or footing group. The submittal shall address the Contractor's proposed time delay and/or the minimum concrete strength necessary before initiating a shaft excavation adjacent to a recently installed drilled shaft.
 - (3) Shaft Excavation. A site specific step by step description of how the Contractor anticipates the shaft excavation to be advanced based on their evaluation of the subsurface data and conditions expected to be encountered. This sequence shall note the method of casing advancement, anticipated casing lengths, tip elevations and diameters, the excavation tools used and drilled diameters created. The Contractor shall indicate whether wet or dry drilling conditions are expected or if the water table will be sealed from the excavation.
 - (4) Slurry Quality Control. When the use of slurry is proposed, details covering the measurement and control of the hardness of the mixing water, agitation, circulation, de-sanding, sampling, testing, and chemical properties of the slurry shall be submitted.
 - (5) Shaft Cleaning and Inspection. Method(s) and sequence proposed for the shaft cleaning operation as well as recommendations on how the shaft excavation will be inspected under the installation conditions anticipated.
 - (6) Reinforcement Placement. Details of reinforcement placement including cage centralization devices to be used and method to maintain proper elevation and plan location of cage within the shaft excavation

during concrete placement. The method(s) of adjusting the cage length if rock is encountered at an elevation other than as shown on the plans.

- (7) Concrete Placement. Details of concrete placement including proposed operational procedures for free fall, tremie or pumping methods. The sequence and method of casing removal shall also be stated along with the top of pour elevation, and method of forming through water above streambed.
- (8) Mix Design. The proposed concrete mix design(s).

The Engineer will evaluate the drilled shaft installation procedure and notify the Contractor of acceptance, need for additional information, or concerns with the installation's effect on the existing or proposed structure(s).

CONSTRUCTION REQUIREMENTS

516.05 General. Excavation for drilled shaft(s) shall not proceed until written authorization is received from the Engineer. The Contractor shall furnish an installation log for each shaft installed. The Contractor shall be responsible for verification of the dimensions and alignment of each shaft excavation as directed by the Engineer.

Unless otherwise approved in the Contractor's installation procedure, no shaft excavation shall be made within four shaft diameters center to center of a shaft with concrete that has a compressive strength less than 1500 psi (10,300 kPa). The site-specific soil strengths and installation methods selected will determine the actual required minimum spacing, if any, to address vibration and blow out concerns.

516.06 Construction Methods. The construction of drilled shafts may involve the use of one or more of the following methods to support the excavation during the various phases of shaft drilling, cleaning, and concrete placement dependent on the site conditions encountered. Surface water shall not be permitted to enter the hole.

The following are general descriptions indicating the conditions when these methods may be used.

- (a) Dry Method. The dry method consists of drilling the shaft excavation, removing accumulated water and loose material from the excavation, and placing the reinforcing cage and concrete in a predominately dry excavation. This method shall be used only at sites where the groundwater and soil conditions are suitable to permit the drilling and dewatering of the excavation without causing excessive water infiltration, boiling, squeezing, or caving of the shaft side walls. This method allows the concrete placement by tremie or concrete pumps, or if the excavation can be dewatered, the concrete can be placed by free fall within the limits specified for concrete placement according to Article 516.12.
- (b) Wet Method. The wet construction method may be used at sites where dewatering the excavation would cause collapse of the shaft sidewalls or when the volume and head of water flowing into the shaft is likely to

contaminate the concrete during placement resulting in a shaft defect. This method uses water or slurry to maintain stability of the shaft perimeter while advancing the excavation. After the excavation is completed, the water level in the shaft is allowed to seek equilibrium, the base is cleaned, the reinforcing cage is set, and the concrete is discharged at the base using a tremie pipe or concrete pump, displacing the drilling fluid upwards.

- (c) Temporary Casing Method. Temporary casing shall be used when either the wet or dry methods provide inadequate support to prevent sidewall caving or ensure excessive deformation of the hole. Temporary casing may also be used to reduce the flow of water into the excavation to allow dewatering, adequate cleaning, and inspection, or to insure proper concrete placement. Temporary casing left in place may constitute a shaft defect; no temporary casing will be allowed to remain permanently in place without the specific approval of the Engineer.

Before the temporary casing is broken loose, the level of concrete in the casing shall be a minimum of 5 ft (1.5 m) above the bottom of the casing. The casing shall not be broken loose by any method which may cause separation of the concrete. After being broken loose and as the casing is withdrawn, additional concrete shall be added to maintain sufficient head so that water and soil trapped behind the casing can be displaced upward and discharged at the ground surface without contaminating the concrete in the shaft or at the finished construction joint.

- (d) Permanent Casing Method. When called for on the plans or proposed as part of the Contractor's accepted installation procedure, the Contractor shall install a permanent casing of the diameter, length, thickness, and strength specified. When permanent casings are used, the lateral loading design requires intimate contact between the casing and the surrounding soils. If the installation procedure used to set the permanent casing results in annular voids between the permanent casing and the drilled excavation, the voids shall be filled with a grout to maintain the lateral load capacity of the surrounding soil, as assumed in the design. No permanent casing will be allowed to remain in place beyond the limits shown on the plans without the specific approval of the Engineer. A grout mix shall be used to fill any visible gaps, which may exist between the permanent casing and either the drilled excavation or temporary casing.
- (e) Removable Forms. When the shaft extends above the streambed through a body of water and permanent casing is not shown, the portion above the streambed shall be formed with removable casings, column forms, or other forming systems as approved by the Engineer. The forming system shall not scar or spall the finished concrete or leave in place any forms or casing within the removable form limits as shown on the plans unless approved as part of the installation procedure. The forming system shall not be removed until the concrete has attained a minimum compressive strength of 2500 psi (17,200 kPa) and cured for a minimum of 72 hours. For shafts extending through water, the concrete shall be protected from water action after placement for a minimum of seven days.

516.07 Slurry. If the Contractor proposes to use a method of slurry construction, it shall be submitted with the installation plan. Measures for preventing anomalies from sand fallout shall be included in the plan. During construction, the level of the slurry shall be maintained at a height sufficient to prevent caving of the hole. In the event of a sudden or significant loss of slurry to the hole, the construction of that foundation shall be stopped and the shaft excavation backfilled or supported by temporary casing, until a method to stop slurry loss, or an alternate construction procedure has been approved by the Engineer.

516.08 Excavation Cleaning and Inspection. Materials removed or generated from the shaft excavations shall be disposed of according to Article 202.03.

After excavation, each shaft shall be cleaned. The cleaning operation shall result in at least 50 percent of the base of each shaft having less than 1/2 in. (13 mm) of sediment or debris at the time of concrete placement. The depth of sediment or debris at any place on the base of the shaft shall be a maximum of 1 1/2 in. (38 mm).

Shaft cleanliness shall be determined using the methods as accepted in the installation procedure.

A shaft excavation shall be overreamed when, in the opinion of the Engineer, the sidewall has softened, swelled, or has a buildup of slurry cake. Overreaming may also be required to correct a shaft excavation which has been drilled out of tolerance. Overreaming may be accomplished with a grooving tool, overreaming bucket, or other approved equipment. Overreaming thickness shall be a minimum of 1/2 in. (13 mm).

516.09 Top of Rock. The top of rock will be considered as the point where rock, defined as bedded deposits and conglomerate deposits exhibiting the physical characteristics and difficulty of rock removal as determined by the Engineer, is encountered which cannot be drilled with earth augers and/or underreaming tools configured to be effective in the soils indicated in the contract documents, and requires the use of special rock augers, core barrels, air tools, blasting, or other methods of hand excavation.

516.10 Design Modifications. If the top of rock elevation differs from that shown on the plans by more than 10 percent of the length of the shaft above the rock, the Engineer shall be contacted to determine if any drilled shaft design changes may be required. In addition, if the type of soil or rock encountered is not similar to that shown in the subsurface exploration data, the Contractor may be required to extend the drilled shaft length(s) beyond those specified in the plans. In either case, the Engineer will determine if revisions are necessary and the extent of the modifications required.

516.11 Reinforcement. This work shall be according to Section 508 and the following.

The shaft excavation shall be cleaned and inspected prior to placing the reinforcement cage. The reinforcement cage shall be completely assembled prior to drilling and be ready for adjustment in length as required by the conditions encountered. The cage shall be lifted using multiple point sling straps or other

approved methods to avoid cage distortion or stress. Additional cross frame stiffeners may also be required for lifting or to keep the cage in proper position during lifting and concrete placement.

The Contractor shall attach suitable cage centralizers to keep the cage away from the sides of the shaft excavation during placement and to ensure that at no point will the finished shaft have less than the minimum concrete cover(s) shown on the plans. The cage centralizers or other approved non-corrosive spacing devices shall be used at sufficient intervals (near the bottom and at intervals not exceeding 10 ft (3 m) throughout the length of the shaft) to ensure proper cage alignment and clearance for the entire shaft.

If the conditions differ such that the length of the shaft is increased, additional longitudinal bars shall be either mechanically spliced or lap spliced to the lower end of the cage and confined with either hoop ties or spirals. The Contractor shall have additional reinforcement available or fabricate the cages with additional length as necessary to make the required adjustments in a timely manner as dictated by the encountered conditions. The additional reinforcement may be non-epoxy coated. Any reinforcement fabricated in advance but not incorporated into the shaft(s) shall remain the property of the Contractor.

516.12 Concrete Placement. Concrete work shall be performed according to Section 503 and the following.

Concrete shall be placed as soon as possible after reinforcing steel is set and secured in proper position. The pour shall be made in a continuous manner from the bottom to the top elevation of the shaft as shown on the contract plan or as approved in the Contractor's installation procedure. Concrete placement shall continue after the shaft excavation is full and until good quality, uncontaminated concrete is evident at the top of shaft. The elapsed time from the beginning of concrete placement in the shaft to the completion of the placement shall not exceed two hours. At no time during construction shall the slump loss result in a slump below the minimum specified. The Contractor may request a longer placement time provided the concrete mix maintains the minimum specified slump requirements over the longer placement time as demonstrated by trial mix and slump loss tests. Vibration of the concrete will not be allowed when the concrete is displacing drilling fluid or water. In dry excavations, the concrete in the top 10 ft (3 m) of the shaft shall be vibrated.

When the top of the shaft is at the finished elevation and no further concrete placement above the finished elevation is specified, the top of the shaft shall be level and finished according to Article 503.15(a).

Concrete shall be placed by free fall, tremie, or concrete pump subject to the following conditions.

- (a) Free Fall Placement. The free fall placement shall only be permitted in shafts that can be dewatered to ensure less than 3 in. (75 mm) of standing water exist at the time of placement without causing side wall instability. The height of free fall placement shall be a maximum of 60 ft (18.3 m). Concrete placed by free fall shall fall directly to the base without contacting either the rebar cage or shaft sidewall. Drop chutes may be used to direct concrete to the base during free fall placement.

Drop chutes used to direct placement of free fall concrete shall consist of a smooth tube of either one continuous section or multiple pieces that can be added and removed. Concrete may be placed through either a hopper at the top of the tube or side openings as the drop chute is retrieved during concrete placement. The drop chute shall be supported so that the free fall does not exceed 60 ft (18.3 m) at all times and to ensure the concrete does not strike the rebar cage. If placement cannot be satisfactorily accomplished by free fall in the opinion of the Engineer, either a tremie or pumping shall be used to accomplish the pour.

- (b) Tremies and Concrete Pumps. Tremies shall consist of a tube of sufficient length, weight, and diameter to discharge the initial concrete at the base of the shaft. The tremie shall be according to Article 503.08 and contain no aluminum parts that may have contact with the concrete. The inside and outside surfaces of the tremie shall be clean and smooth to permit both flow of concrete and unimpeded withdrawal during concrete placement.

Pumps and lines may be used for concrete placement and shall have a minimum 4 in. (100 mm) diameter.

Tremies and pump lines shall be pre-lubricated with a cement/water mixture, and the excess material wasted before concrete placement begins.

The tremie or pump lines used for wet method concrete placement shall be watertight and not begin discharge until placed within 10 in. (250 mm) of the shaft base. Valves, bottom plates, or plugs may be used only when they can be removed from the excavation or be of a material approved by the Engineer that will not cause a defect in the shaft if not removed. The discharge end shall be immersed at least 5 ft (1.5 m) in concrete at all times after starting the pour. Sufficient concrete head shall be maintained in the tremie at all times to prevent water or slurry intrusion in the shaft concrete.

516.13 Construction Tolerances. The following construction tolerances shall apply to all drilled shafts.

- (a) Center of Shaft. The center of the drilled shaft shall be within 3 in. (75 mm) of the plan station and offset at the top of the shaft.
- (b) Center of Reinforcement Cage. The center of the reinforcement cage shall be within 1 1/2 in. (40 mm) of plan station and offset at the top of the shaft.
- (c) Vertical Plumbness of Shaft. The out of vertical plumbness of the shaft shall not exceed 1.5 percent.
- (d) Vertical Plumbness of Reinforcement Cage. The out of vertical plumbness of the shaft reinforcement cage shall not exceed 0.83 percent.
- (e) Top of Shaft. The top of the shaft shall be no more than 1 in. (25 mm) above and no more than 3 in. (75 mm) below the plan elevation.

- (f) Top of Reinforcement Cage. The top of the reinforcing steel cage shall be no more than 1 in. (25 mm) above and no more than 3 in. (75 mm) below the plan elevation.
- (g) Excavation Equipment. Excavation equipment and methods used to complete the shaft excavation shall have a nearly planar bottom. The cutting edges of excavation equipment used to create the bottom of shafts in rock shall be normal to the vertical axis of the shaft within a tolerance of 6.25 percent.

516.14 Obstructions. Obstructions shall be defined as any object that cannot be removed with normal earth drilling procedures, but requires special augers, tooling, core barrels, or rock augers to remove the obstruction. When obstructions are encountered, the Contractor shall notify the Engineer and upon concurrence of the Engineer, the Contractor shall begin working to core, break up, push aside, or remove the obstruction.

516.15 Method of Measurement. This work will be measured for payment in place and the volume computed in cubic yards (cubic meters). The volume will be computed using the plan diameter of the shaft multiplied by the measured length of the shaft. The length of shaft in soil will be computed as the difference in elevation between the top of the drilled shaft shown on the plans, or as installed as part of the Contractor's installation procedure, and the bottom of the shaft or the top of rock (when present) whichever is higher. The length of shaft in rock will be computed as the difference in elevation between the measured top of rock and the bottom of the shaft.

When permanent casing is specified, it will be measured for payment in place, in feet (meters). Permanent casing installed at the Contractor's option will not be measured for payment.

Reinforcement furnished and installed will be measured for payment according to Article 508.07.

516.16 Basis of Payment. This work will be paid for at the contract unit price per cubic yard (cubic meter) for DRILLED SHAFT IN SOIL, and/or DRILLED SHAFT IN ROCK.

Permanent casing will be paid for at the contract unit price per foot (meter) for PERMANENT CASING.

Reinforcement furnished and installed will be paid for according to Article 508.08.

Obstruction mitigation will be paid for according to Article 109.04.

SECTION 520. BRIDGE EXPANSION JOINTS

520.01 Description. This work shall consist of constructing bridge expansion joints.

520.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Preformed Elastomeric Joint Seals for Bridge Decks	1053.02
(b) Preformed Elastomeric Strip Seals for Bridge Decks	1053.03
(c) Structural Steel	1006.04
(d) Neoprene Expansion Joint	1052
(e) Stud Shear Connectors	1006.32
(f) Fabric Reinforced Elastomeric	1028
(g) Stainless Steel Hardware	1006.29(d)
(h) Chemical Adhesive Resin System	1027.01

CONSTRUCTION REQUIREMENTS

520.03 Steel Fabrication. The plates, angles, and other structural shapes supporting joint seals shall be fabricated to satisfy shop drawing details and conform to the configuration of the concrete deck or sidewalk. The fabrication shall be according to Articles 505.04 through 505.10. The anchor studs shall be welded prior to painting or galvanizing.

For finger plate expansion joints the fabricator shall be certified according to Article 106.08(b) and shop drawings shall be submitted according to Article 505.03. For other joints, shop drawings need not be submitted for approval before fabrication, but the manufacturer shall supply them with the completed joint to the Contractor and Engineer.

The manufacturer shall have current, pre-approved shop standards detailing the various standard components for the joint system(s) supplied on file with the Department prior to installation. The pre-approved shop standards shall be included with the shop drawings.

After fabrication, the steel plates or locking edge rail supports shall receive one shop coat of paint according to Section 506. At the manufacturer's option, the steel components may be hot dip galvanized according to AASHTO M 111 and ASTM A 385 in lieu of shop painting.

520.04 Joint Opening. The components of the joint system shall be properly aligned and set prior to casting them into the deck or anchorage material. The joint opening shall be measured parallel to centerline of roadway and shall be adjusted according to the temperature at the time of placing so that the specified opening will be secured at a temperature of 50 °F (10 °C). The opening for each 100 ft (10 m) of bridge between the nearest fixed bearings each way from the joint shall be reduced 1/8 in. (1 mm) corrected for skew from the amount specified, for each 15 °F (8 °C) the temperature at the time of placing exceeds 50 °F (10 °C) and increased 1/8 in.

(1 mm) corrected for skew from the amount specified, for each 15 °F (8 °C) the temperature at the time of placing is below 50 °F (10 °C).

520.05 Joint Preparation. Prior to installation of the joint seal, all thin shells of mortar and projections of concrete into and around the joint space likely to spill under movement or prevent the proper operation of the joint shall be carefully removed and all forms and debris shall be removed from the joint opening.

520.06 Preformed Elastomeric Joint Seals. Joints shall be clean immediately prior to application of the adhesive. Temperature limitations of the adhesive, as specified by the manufacturer, shall be observed. The seal shall be installed in a compressed condition and secured in place with adhesive covering both sides of the seal over the full area in contact with the sides of the joint. The seal shall be in one continuous piece for the full length of the joint. The continuous piece for installation shall not have more than one manufacturer's butt splice within its length. If the splice is torn or damaged, the seal shall be replaced.

520.07 Neoprene Expansion Seals. The neoprene expansion seals shall be installed according to the manufacturer's specifications, shop drawings, and as specified herein. The shop drawings, along with joint details, shall include details of the concrete blockout, if required for the installation, a layout plan of the joint units to be used, and the spacing and location of the anchor bolts or studs.

Anchors shall be properly positioned by the use of a suitable template and shall be cast-in-place bolts or by drilling and setting anchor rods according to Article 509.06.

Concrete or metal surfaces on which the neoprene expansion joints are to be set shall be dry, clean, level, and sound with no broken or spalled concrete. Adjacent joint seats shall be on a common plane with each other. Joint seals shall not be placed until the Engineer has approved the blockout. Errors shall be corrected by grinding or other approved procedures, including, if necessary, concrete removal and replacement to obtain proper alignment.

The neoprene molded sealing element shall be furnished and installed in one continuous, unbroken length for the entire joint length including parapets, curbs, and walls. The seal shall be installed in an adhesive/sealant bedding compound in the blockout as shown on the plans. Neoprene surfaces to be in contact with adhesive shall be cleaned with a solvent as recommended by the manufacturer, prior to installation. The adhesive/sealant shall be liberally applied over the entire blockout or metal seat area as the sealing element is set into it. The anchor blocks shall then be set in position over the seal with the nuts torqued to at least 65 ft lb (90 N m). A minimum of 24 hours after initial installation, the nuts shall be retorqued to the initial 65 ft lb (90 N m).

Prior to filling the space in the bolt wells, the Engineer's inspection of the anchor fasteners and tightening of the units will be required. All joints between units, around connecting bolts, and cavity plugs shall be sealed in a neat manner. Neoprene surfaces to be in contact with sealant shall be cleaned with a solvent as recommended by the manufacturer prior to sealing.

Where longitudinal joints intersect with transverse joint seals, a positive seal shall be provided by flattening and extending the longitudinal joint neoprene seal element under the transverse joint pad. When this procedure is not practical, a separate neoprene apron, bonded to the longitudinal seal element, may be used.

The finished joint shall present a smooth, neat appearance with no protruding bolts or rough joints. Excess sealant shall be wiped or scraped away before it becomes hard. Upon completion of an entire joint, the Contractor shall grind any uneven end butt connections flush. Any openings between butt ends not showing sealant to the top shall be cleaned and filled with sealant. Where the joint pads are inset into the concrete blockouts, the edges between the concrete and the pads shall be sealed with sealant. When the bridge deck is to be waterproofed and surfaced, the installation of the joint shall be completed prior to placement of the deck waterproofing and hot-mix asphalt (HMA) surfacing.

520.08 Preformed Elastomeric Strip Seals. Preformed elastomeric strip seals (strip seals) shall be installed according to the manufacturer's specifications and as specified herein.

The steel locking edge support rails for strip seals shall be either a one-piece extrusion (rolled section) or a combination of extruded and stock plate, shop welded according to Section 505. The locking portion of the steel edge support rail shall be extruded, with a cavity, properly shaped to allow the insertion of the strip seal gland and the development of a mechanical interlock. The top of the steel edge support rails shall be smooth and free of burrs.

Preparation and placement of the gland will only be allowed after the anchoring material has fully cured.

Prior to placement of the strip seal, the cavity shall be cleaned of debris. Surface rusting shall be removed and any bare steel touched up according to Article 506.05. The steel extrusion cavities shall be kept clean and dry until the strip seal is placed.

The placement of the strip seal will only be permitted when the ambient air and steel substrate temperatures are above the minimum temperature recommended by the manufacturer. Prior to inserting the strip seal in the steel retainer cavities, the "locking ears" portion of the seal shall be coated with adhesive/lubricant. A maximum of 5 ft (1.5 m) of gland shall be coated at a time to prevent the lubricant/adhesive from drying prior to insertion into the cavities of the steel locking edge rails. After each section is coated, the coated portion of the seal shall be inserted in the steel locking edge rail cavities.

520.09 Finger Plate Expansion Joint. This work shall include all stools, shims, sliding and bent plates, fabric reinforced elastomeric trough, and other associated hardware necessary to construct the finger plate joint as detailed.

The fabric reinforced elastomeric trough and flaps shall not be installed until all structural steel has been field painted. The trough shall be installed with the smooth elastomer compound surface on the inside of the trough. For abutment finger plate joints the trough shall be connected to the abutment backwall with predrilled anchor bolts utilizing the 1/4 x 2 in. (6 x 50 mm) plate as a template for drilling the holes. Cast in place concrete inserts will not be allowed. Following installation of the trough

flattening plate, a suitable sealant shall be applied to prevent leakage between the trough and the backwall.

520.10 End Treatment. The end treatment for curbs, parapets, and sidewalks shall be as detailed on the plans and as recommended by the manufacturer of the joint system.

520.11 Technical Support. The manufacturer shall supply technical support during surface preparation and the installation of the entire joint system.

520.12 Method of Measurement. This work will be measured for payment in place, in feet (meters), along the centerline of the joint.

When paid for as a separate item, fabric reinforced elastomeric trough will be measured for payment in place, in feet (meters), along the centerline of the trough flow line.

520.13 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for PREFORMED JOINT SEAL, of the design movement specified; PREFORMED JOINT STRIP SEAL, or FINGER PLATE EXPANSION JOINT, of the design movement specified; NEOPRENE EXPANSION JOINT, of the expansion range specified; or NEOPRENE EXPANSION JOINT (DAM).

When a pay item is provided in the contract, the trough for finger plate expansion joints and all associated hardware will be paid for at the contract unit price per foot (meter) for FABRIC REINFORCED ELASTOMERIC TROUGH.

SECTION 521. BEARINGS

521.01 Description. This work shall consist of furnishing and installing bearings.

521.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Elastomeric Bearings	1083
(b) Structural Steel	1006.04
(c) Anchor Bolts and Rods	1006.09

CONSTRUCTION REQUIREMENTS

521.03 Metal Bearings. Metal bearings and metal bearing components shall be fabricated according to Section 505. Exposed surfaces and other portions of the structural steel bearing plates shall be painted according to Article 506.05. During cleaning and painting, the stainless steel and PTFE sheet sliding surfaces and elastomers shall be protected from abrasion and paint.

521.04 Shipping and Handling. The bearing assemblies shall be furnished as a complete unit from one manufacturing source. Bearing assemblies shall be

furnished, packaged, and handled in such a manner that the bearing assembly will be protected from damage.

521.05 Setting of Bearings. Fixed and expansion bearings on concrete shall be set level and not be placed upon areas that are improperly finished, damaged, or irregular. The concrete under each bearing shall be finished smooth and level, within 1/8 in. (3 mm) of the specified elevation before the bearings are placed.

The location of expansion bearings shall correspond with the temperature at the time of erection.

Leveling plates, pads, and/or adjustment shims shall be placed as shown on the plans.

Bearing plates to be cast into concrete superstructures shall be secured in the proper position, and all wedges or blocking used to position expansion bearings shall be removed as soon as practicable after the concrete is placed.

521.06 Anchor Bolts, Rods, and Side Retainers. Anchor bolts and rods shall be hot-dip galvanized. Side retainers shall be painted according to Article 505.06 or hot-dip galvanized according to Article 506.04.

Anchor rods shall be drilled and set according to Article 509.06, except where anchor bolts are cast into the concrete. Before setting anchor rods with chemical adhesive, hole depths and diameters in the concrete will be verified. Holes shall be kept dry and shall be blown clean prior to installing the anchor rods.

After the anchors are installed, the upper end will be checked to verify proper embedment. Anchor lengths shall leave the exposed end projecting between 1/2 in. (13 mm) and 2 in. (50 mm) above the top of the nut. Nuts for anchors in non-moving elements shall be installed snug tight by a few impacts of an impact wrench or the full force of a worker using an ordinary spud wrench. The nuts on anchors through moving parts at expansion bearings shall be adjusted to provide clearance as shown on the plans.

All side retainers shall be secured in place prior to forming the bridge deck.

521.07 Work Under Separate Contracts. When the fabrication and erection of elastomeric bearings and other collateral work are accomplished under separate contracts, the requirements of Article 505.09 shall apply.

521.08 Method of Measurement. Elastomeric bearings will be measured for payment as each. When paid for as a separate item, steel bearings, will be measured for payment as each. Each will be defined as one complete bearing assembly.

When paid for as a separate item, anchor bolts will be measured for payment as each. Each will be defined as an anchor bolt assembly which shall include all washers, nuts, and chemical adhesive necessary to install one anchor bolt.

521.09 Basis of Payment. Elastomeric bearings fabricated and erected under a single contract will be paid for at the contract unit price per each for ELASTOMERIC BEARING ASSEMBLY, of the type specified.

Elastomeric bearings fabricated under a separate contract will be paid for at the contract unit price per each for FURNISHING ELASTOMERIC BEARING ASSEMBLY, of the type specified. Storage and care of fabricated elastomeric bearings by the fabrication Contractor beyond the specified storage period, will be paid for at the contract unit price per calendar day for STORAGE OF ELASTOMERIC BEARING ASSEMBLIES when a pay item is provided for in the contract, or will be paid for according to Article 109.04 when a pay item is not provided for in the contract.

Elastomeric bearings erected under a separate contract will be paid for at the contract unit price per each for ERECTING ELASTOMERIC BEARING ASSEMBLY, of the type specified.

When an elastomeric bearing is requested by the Department for testing, the furnishing and delivering of the additional bearing assembly will be paid for according to Article 109.04.

When steel bearings are paid for separately, this work will be paid for at the contract unit price per each for STEEL BEARING ASSEMBLY.

When paid for as a separate item, anchor bolts will be paid for at the contract unit price per each for ANCHOR BOLTS, of the diameter specified.

CULVERTS

SECTION 540. BOX CULVERTS

540.01 Description. This work shall consist of constructing cast-in-place concrete and precast concrete box culverts.

540.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Cast-In-Place Culverts	503.02
(b) Precast Culverts	1042.05
(c) Coarse Aggregate (Note 1)	1004.05
(d) Mastic Joint Sealer for Pipe	1055
(e) External Sealing Band	1057
(f) Handling Hole Plugs	1042.16

Note 1. The porous granular material placed below a precast box shall be gradation CA 7, CA 11, or CA 18.

540.03 Equipment. Equipment shall be according to Articles 503.03 and 504.03.

CONSTRUCTION REQUIREMENTS

540.04 General. Cast-in-place concrete box culverts shall be constructed according to the applicable portions of Section 503.

The Contractor shall have the option, when a cast-in-place concrete box culvert is specified, of constructing the box culvert using precast box culvert sections when the design cover is 6 in. (150 mm) minimum. The precast box culvert sections shall be designed for the same design cover and live load shown on the plans for cast-in-place box culvert and shall be of equal or larger size opening.

The Contractor shall be responsible for diverting the water flow from the construction area using a method meeting the approval of the Engineer.

The excavation and backfilling for concrete box culverts shall be according to Section 502.

540.05 Cast-In-Place Concrete Box Culverts. Concrete culvert footings shall be considered as consisting of all monolithic wingwall footings, all curtain walls below the flow line of the barrel, the base slab, and the sidewalls and wingwalls to a height of approximately 6 in. (150 mm) above the base slab.

The footings shall be placed as a monolith and allowed to set for a period of time sufficient to preclude the possibility of damage by subsequent work. In the construction of box culverts 6 ft (2 m) or less in vertical clearance, the side walls and top slab may be constructed as a monolith in the same placing operations. When this method of construction is used, any necessary construction joints shall be vertical and at right angles to the axis of the culvert. In box culverts of sufficient size to prohibit that part above the footing being completed in one continuous operation, horizontal construction joints will be permitted below the top slab at locations shown on the plans. A horizontal construction joint will be required below the top slab of any culvert having a vertical clearance of more than 6 ft (2 m).

Cast-in-place concrete culvert slabs built to roadway grade shall be finished according to Article 503.16(a).

540.06 Precast Concrete Box Culverts. End sections may be precast or cast-in-place. Cast-in-place end sections shall include all cast-in-place collars, headwalls, cutoff walls, wingwalls, footings, and reinforcement necessary to complete the end sections.

Where cast-in-place headwalls and vertical cantilever wingwalls are used as shown in the contract plans, they shall be collared around the end of the precast section. Where cast-in-place horizontal cantilever wingwalls are used as shown in the contract plans, they shall be poured monolithically with at least 6 ft (2 m) of cast-in-place box section. The cast-in-place box section shall be collared around the end of the precast section. The cast-in-place collars shall be reinforced.

Shop drawings shall be submitted according to Article 1042.03(b) for all precast concrete box culvert sections, precast or cast-in-place end sections and headwalls, and cast-in-place collars. Shop drawings for precast concrete box culvert sections

which satisfy the standard shapes, reinforcement, and detailing of ASTM C 1577 are not required to be reviewed and approved by the Engineer.

The excavation and backfilling for precast concrete box culverts shall be according to the requirements of Section 502, except a layer of porous granular material, at least 6 in. (150 mm) in thickness, shall be placed below the elevation of the bottom of the box. The porous granular material shall extend at least 2 ft (600 mm) beyond each side of the box. The precast concrete box culvert shall be laid according to the applicable requirements of Article 542.04(d). After installation, the interior and exterior joint gap between precast concrete box culvert sections shall be a maximum of 1 1/2 in. (38 mm).

The joints between precast box sections shall be sealed and all voids filled with a mastic joint sealer. In addition, the joints shall be externally sealed on the sides and top using 13 in. (325 mm) wide external sealing bands. Prior to applying the sealing band, the concrete surface shall be cleaned to remove dirt or laitance and allowed to dry. The sealing band shall be centered over the joint, secured in place, and protected from damage during the backfilling operation.

When multi-cells are used, a 3 in. (75 mm) nominal space shall be left between adjacent sections. After the precast cells are in place and backfill has been placed to midheight of the precast concrete box sections on each side, the space between the cells shall be filled with Class SI concrete. The Class SI concrete shall be according to Section 1020, except the maximum size coarse aggregate shall be 3/8 in. (10 mm).

Handling holes shall be filled with a precast concrete plug and sealed with mastic or mortar, or filled with a polyethylene plug. The plug shall not project beyond the inside surface after installation. When metal lifting inserts are used, their sockets shall be filled with mastic or mortar.

540.07 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Concrete for cast-in-place box culverts will be measured for payment in cubic yards (cubic meters) as specified in Article 503.21.

Reinforcement bars for cast-in-place concrete box culverts will be measured for payment in pounds (kilograms) as specified in Article 508.07.

When precast concrete box culverts are specified on the plans, they will be measured for payment in feet (meters), except the length measured shall not exceed the length shown on the plans or authorized by the Engineer. The overall length shall be measured as shown on the plans along the centerline of each cell of the culvert. The end sections will be measured for payment in place as each.

Excavation in rock will be measured for payment according to Article 502.12.

Art. 540.07 Corrugated Structural Plate Drainage Structures

The volume of any unstable and/or unsuitable material removed below plan bedding grade will be measured for payment in cubic yards (cubic meters).

540.08 Basis of Payment. Cast-in-place concrete box culverts will be paid for at the contract unit price per cubic yard (cubic meter) for CONCRETE BOX CULVERTS. Reinforcement will be paid for according to Article 508.08.

Expansion bolts will be paid for at the contract unit price per each for EXPANSION BOLTS of the size indicated.

When specified on the plans, precast concrete box culverts will be paid for at the contract unit price per foot (meter) for PRECAST CONCRETE BOX CULVERTS of the size specified.

End sections will be paid for at the contract unit price per each for BOX CULVERT END SECTIONS of the culvert number specified. If the Contractor, with the approval of the Engineer, elects to use a different end section from that shown on the plans, no adjustment in the cost of the precast box culverts or end sections will be allowed.

When the plans specify cast-in-place concrete box culvert and the Contractor, at his/her option, constructs the alternate precast concrete box culvert, no adjustment in the cost for the specified cast-in-place culvert will be allowed. Compensation under the contract bid items for concrete box culverts and reinforcement bars shall cover the cost of the precast concrete box culvert alternate complete.

Excavation in rock will be paid for according to Article 502.13.

Removal and disposal of unstable and/or unsuitable material below plan bedding grade will be paid for according to Article 502.13.

SECTION 541. CORRUGATED STRUCTURAL PLATE DRAINAGE STRUCTURES

541.01 Description. This work shall consist of furnishing and installing corrugated structural plate pipe culverts, corrugated structural plate pipe arches and corrugated structural plate arches, fabricated and erected in sections.

541.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Corrugated Structural Plate Pipe, Pipe Arches, and Arches (Note 1) (Note 2).....	1006.02
(b) Fine Aggregate	1003.04
(c) Portland Cement Concrete	1020

Note 1. The Department reserves the right to specify either steel or aluminum alloy. When a particular material is specified, no other material will be permitted.

Note 2. All steel channels, angles, bolts, washers, or other hardware shall be galvanized by the hot-dip process after fabrication.

When metric sizes are specified on the plans, the next larger available manufactured English size may be used at no additional cost to the Department.

541.03 Plates. Plates shall consist of structural units of steel or aluminum alloy furnished in standard sizes to permit structure length increments of 2 ft (600 mm). The corrugations shall run at right angles to the longitudinal axis of the structure.

The plates at longitudinal and circumferential seams shall be staggered so that not more than three plates come together at one point.

The minimum cover over the top of corrugated structural plate drainage structures shall be as shown in Tables I and II for structural plate pipes and pipe arches. The minimum cover for arches shall be one sixth of the span length, but not less than 1 ft (300 mm).

Plates for corrugated structural plate pipe culverts and for corrugated structural plate pipe arches shall be furnished in the thickness shown in Tables I and II for the respective size and cover over the pipe.

Plates for corrugated structural plate arches shall be furnished in the thickness shown on the plans.

TABLE IA Wall Thickness (inches) for Corrugated Steel Structural Plate Pipe Culverts for H-20 Loading															
Dia. of Pipe (in.)	Height of Cover to Nearest Foot														
	1.0*	1.5*	2.0* thru 14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0	23.0	24.0	25.0	26.0
60.0	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
66.0	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
72.0	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
78.0	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
84.0	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
90.0	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
96.0	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
102.0		0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.140	0.140
108.0		0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.140	0.140
114.0		0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.140	0.140	0.140
120.0		0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.140	0.140	0.140	0.140
126.0		0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.140	0.140	0.140	0.140	0.140
132.0		0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.140	0.140	0.140	0.140	0.140	0.140
138.0		0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.140	0.140	0.140	0.140	0.140	0.140	0.140
144.0		0.111	0.111	0.111	0.111	0.111	0.111	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140
150.0			0.111	0.111	0.111	0.111	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140
156.0			0.111	0.111	0.111	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140
162.0			0.111	0.111	0.111	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140
168.0			0.111	0.111	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140
174.0			0.111	0.111	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.170
180.0			0.111	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.170	0.170
Required minimum cover.															

* Required minimum cover.

TABLE IA continued Wall Thickness (inches) for Corrugated Steel Structural Plate Pipe Culverts for H-20 Loading														
Dia. of Pipe (in.)	Height of Cover to Nearest Foot													
	27.0	28.0	29.0	30.0	31.0	32.0	33.0	34.0	35.0	36.0	37.0	38.0	39.0	40.0
60.0	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
66.0	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
72.0	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.140	0.140	0.140	0.140
78.0	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.140	0.140	0.140	0.140	0.140	0.140	0.140
84.0	0.111	0.111	0.111	0.111	0.111	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140
90.0	0.111	0.111	0.111	0.111	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140
96.0	0.111	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140
102.0	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140
108.0	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140
114.0	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.170
120.0	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.170	0.170	0.170	0.170
126.0	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.170	0.170	0.170	0.170	0.170	0.170
132.0	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.170	0.170	0.170	0.170	0.170	0.170	0.170
138.0	0.140	0.140	0.140	0.140	0.140	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170
144.0	0.140	0.140	0.140	0.140	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170
150.0	0.140	0.140	0.140	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170
156.0	0.140	0.140	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.188
162.0	0.140	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.188	0.188
168.0	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.188	0.188	0.188	0.188
174.0	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.188	0.188	0.188	0.188	0.188
180.0	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.188	0.188	0.188	0.188	0.188	0.188

TABLE IA (Metric) Wall Thickness (millimeters) for Corrugated Steel Structural Plate Pipe Culverts for M 18 Loading													
Dia. of Pipe (mm)	Height of Cover to Nearest 0.1 Meter												
	0.3*	0.5*	0.6* thru 4.3	4.6	4.9	5.2	5.5	5.8	6.1	6.4	6.7	7.0	7.3
1500	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
1650	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
1800	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
1950	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
2100	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
2250	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
2400	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
2550	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
2700	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
2850	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
3000	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
3150	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
3300	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
3450	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
3600	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
3750			2.82	2.82	2.82	2.82	3.56	3.56	3.56	3.56	3.56	3.56	3.56
3900			2.82	2.82	2.82	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56
4050			2.82	2.82	2.82	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56
4200			2.82	2.82	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56
4350			2.82	2.82	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56
4500			2.82	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56
* Required minimum cover.													

TABLE IA (Metric) continued Wall Thickness (millimeters) for Corrugated Steel Structural Plate Pipe Culverts for M 18 Loading													
Dia. of Pipe (mm)	Height of Cover to Nearest 0.1 Meter												
	8.2	8.5	8.8	9.1	9.4	9.8	10.1	10.4	10.7	11.0	11.3	11.6	11.9
1500	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
1650	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
1800	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
1950	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
2100	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
2250	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
2400	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
2550	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
2700	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
2850	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
3000	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
3150	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
3300	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
3450	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
3600	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
3750	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
3900	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
4050	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
4200	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
4350	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
4500	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82

TABLE IB
Wall Thickness (inches) for Corrugated Aluminum Alloy Structural Plate Pipe Culverts for H-20 Loading

Dia. of Pipe (in.)	Height of Cover to Nearest Foot														23.0	24.0
	1.0*	1.5*	2.0* thru 10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0	
60.0	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
66.0	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
72.0	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125
78.0	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125
84.0	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125
90.0	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125
96.0	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125
102.0		0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
108.0		0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
114.0		0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150
120.0		0.125	0.100	0.100	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150
126.0		0.125	0.100	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150
132.0		0.125	0.100	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150
138.0		0.125	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.150
144.0		0.125	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.150
150.0			0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.175
156.0			0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.150	0.175	0.175
162.0			0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.150	0.175	0.175	0.175
168.0			0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.150	0.150	0.175	0.175	0.175
174.0			0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.175	0.175	0.175
180.0			0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.175	0.175	0.175	0.200

* Required minimum cover.

TABLE IB continued
Wall Thickness (inches) for Corrugated Aluminum Alloy Structural Plate Pipe Culverts for H-20 Loading

Dia. of Pipe (in.)	Height of Cover to Nearest Foot														39.0	40.0
	25.0	26.0	27.0	28.0	29.0	30.0	31.0	32.0	33.0	34.0	35.0	36.0	37.0	38.0		
60.0	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
66.0	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150
72.0	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.150
78.0	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.150	0.150	0.150	0.150
84.0	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
90.0	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.175
96.0	0.125	0.125	0.125	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.175	0.175	0.175	0.175	0.175
102.0	0.125	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.175	0.175	0.175	0.175	0.175	0.175	0.175
108.0	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.200
114.0	0.150	0.150	0.150	0.150	0.150	0.150	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.200	0.200	0.200
120.0	0.150	0.150	0.150	0.150	0.150	0.175	0.175	0.175	0.175	0.175	0.175	0.200	0.200	0.200	0.200	0.200
126.0	0.150	0.150	0.150	0.175	0.175	0.175	0.175	0.175	0.175	0.200	0.200	0.200	0.200	0.200	0.225	0.225
132.0	0.150	0.150	0.175	0.175	0.175	0.175	0.200	0.200	0.200	0.200	0.200	0.200	0.225	0.225	0.225	0.225
138.0	0.150	0.175	0.175	0.175	0.175	0.175	0.200	0.200	0.200	0.200	0.225	0.225	0.225	0.225	0.250	0.250
144.0	0.175	0.175	0.175	0.175	0.175	0.200	0.200	0.200	0.200	0.225	0.225	0.225	0.250	0.250	0.250	0.250
150.0	0.175	0.175	0.175	0.175	0.200	0.200	0.200	0.200	0.225	0.225	0.225	0.250	0.250	0.250	0.250	
156.0	0.175	0.175	0.175	0.200	0.200	0.200	0.225	0.225	0.225	0.250	0.250	0.250				
162.0	0.175	0.175	0.200	0.200	0.200	0.225	0.225	0.225	0.250	0.250	0.250	0.250				
168.0	0.175	0.200	0.200	0.200	0.225	0.225	0.225	0.250	0.250	0.250						
174.0	0.200	0.200	0.200	0.225	0.225	0.225	0.250	0.250	0.250							
180.0	0.200	0.200	0.225	0.225	0.225	0.250	0.250	0.250								

TABLE IB (Metric)
Wall Thickness (millimeters) for Corrugated Aluminum Alloy Structural Plate Pipe Culverts for M 18 Loading

Dia. of Pipe (mm)	Height of Cover to Nearest 0.1 Meter																
	0.3*	0.5*	0.6* thru 3.0	3.3	3.6	3.9	4.3	4.6	4.9	5.2	5.5	5.8	6.1	6.4	6.7	7.0	7.3
1500	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
1650	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
1800	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
1950	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
2100	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
2250	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
2400	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
2550		2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
2700		2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
2850		2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
3000		3.18	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
3150		3.18	2.54	2.54	2.54	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18
3300		3.18	2.54	2.54	2.54	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18
3450		3.18	2.54	2.54	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18
3600		3.18	2.54	2.54	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18
3750			2.54	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18
3900			3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18
4050			3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18
4200			3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18
4350			3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81
4500			3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81
Required minimum cover.																	

* Required minimum cover.

TABLE IB (Metric) continued
 Wall Thickness (millimeters) for Corrugated Aluminum Alloy Structural Plate Pipe Culverts for M 18 Loading

Dia. of Pipe	Height of Cover to Nearest 0.1 Meter															
	7.6	7.9	8.2	8.5	8.8	9.1	9.4	9.8	10.1	10.4	10.7	11.0	11.3	11.6	11.9	12.2
1500	2.54	2.54	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18
1650	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.81
1800	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.81
1950	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.81
2100	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.81
2250	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.81
2400	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.81
2550	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.81
2700	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	4.44
2850	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	4.44
3000	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	4.44
3150	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	4.44
3300	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	4.44
3450	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	4.44
3600	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	5.08
3750	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	5.08
3900	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	5.08
4050	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	5.08
4200	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	5.08
4350	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08
4500	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08

TABLE IIA
 Sizes, Layout Details, and Wall Thicknesses (inches) for Corrugated Steel Structural Plate Pipe Arches for H-20 Loading

Span (in.)	Rise (in.)	Area (sq ft)	"B" (in.)	Height of Cover to Nearest Foot																
				1.0*	1.5*	2.0*	2.5*	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
73	55	22	21.0	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
76	57	24	20.5	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
81	59	26	22.0	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
84	61	28	21.4	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
87	63	31	20.8	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
92	65	33	22.4	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
95	67	35	21.7	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
98	69	38	20.9	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
103	71	40	22.7		0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
106	73	43	21.8	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
112	75	46	23.8	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
114	77	49	22.9	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
117	79	52	21.9	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
123	81	55	23.9	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
128	83	58	26.1	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
131	85	61	25.1	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
137	87	64	27.4	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109

* Required minimum cover

"B" The horizontal distance from a horizontal line across the widest part of the arch to inside crests of the corrugations of the lowest portion of the arch.

TABLE IIA continued
 Sizes, Layout Details, and Wall Thicknesses (inches) for Corrugated Steel Structural Plate Pipe Arches for H-20 Loading

Span (in.)	Rise (in.)	Area (sq ft)	"B" (in.)	Height of Cover to Nearest Foot											
				1.0*	1.5*	2.0*	2.5*	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
139	89	67	26.3		0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
142	91	71	25.2		0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
148	93	74	27.5			0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
150	95	78	26.4			0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
152	97	81	26.4			0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
154	100	85	24.0			0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
161	101	89	26.3			0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
167	103	93	28.9			0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
159	112	97	38.5			0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
162	114	102	37.7			0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
168	116	105	39.6			0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
170	118	109	38.8			0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
173	120	114	37.9			0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
179	122	118	39.8			0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
184	124	123	41.8			0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
187	126	127	40.9			0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
190	128	132	40.0			0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138
195	130	137	42.1				0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138
198	132	142	41.1				0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138

Bold type indicates areas where soil bearing pressure approximately 3.0 tons/sq ft is required.

* Required minimum cover.

"B" The vertical distance from a horizontal line across the widest part of the arch to inside crests of the corrugations of the lowest portion of the arch.

TABLE IIA (Metric)
 Sizes, Layout Details, and Wall Thicknesses (millimeters) for Corrugated Steel Structural Plate Pipe Arches for M 18 Loading

Span (mm)	Rise (mm)	Area (sq m)	"B" (mm)	Height of Cover to Nearest 0.1 meter																
				0.3*	0.5*	0.6*	0.8*	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.3	3.7	4.0	4.3	4.6
1854	1397	2.0	533	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	
1930	1448	2.2	521	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	
2057	1499	2.4	559	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	
2134	1549	2.6	544	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	
2210	1600	2.9	528	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	
2337	1651	3.1	569	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	
2413	1702	3.3	551	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	
2489	1753	3.5	531	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	
2616	1803	3.7	577	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	
2692	1854	4.0	554	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	
2845	1905	4.3	605	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	
2896	1956	4.6	582	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	
2972	2007	4.8	556	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	
3124	2057	5.1	607	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	
3251	2108	5.4	663	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	
3327	2159	5.7	638	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	
3480	2210	5.9	696	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	

* Required minimum cover.

"B" The vertical distance from a horizontal line across the widest part of the arch to inside crests of the corrugations of the lowest portion of the arch.

TABLE IIB
SIZES, LAYOUT DETAILS, AND WALL THICKNESSES (INCHES) FOR CORRUGATED ALUMINUM ALLOY STRUCTURAL PLATE PIPE ARCHES FOR H-20 LOADING

Span (in.)	Rise	Area (sq ft)	"B" (in.)	Height of Cover to Nearest Foot																
				1.0"	1.5"	2.0"	2.5"	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
71	65	25	31.8	1.0"	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
74	68	27	32.1	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
78	69	30	32.0	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
82	71	32	32.5	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
87	72	35	33.1	0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
91	74	37	33.9	0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
95	76	40	33.7	0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
98	77	42	32.3	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
103	79	45	33.1	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
106	81	48	32.6		0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
111	82	51	33.6	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125
116	84	54	34.6	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125
121	85	57	35.9	0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125
125	87	60	35.3	0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125
128	89	63	34.7	0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125
132	91	66	34.0	0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125
138	92	69	37.5	0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125	0.125
140	94	73	34.6	0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125	0.125
145	95	76	36.0		0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125	0.125
149	97	80	35.2		0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125	0.125
154	99	83	36.8		0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
157	100	87	35.9	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
163	102	91	37.5	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
168	103	94	39.4	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
167	103	102	39.4		0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
171	115	106	42.0	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
176	116	110	44.0	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
179	118	114	43.2	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
184	120	119	45.3	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
187	122	123	44.4	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175
193	124	128	46.6		0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175
196	126	132	45.7		0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175
201	128	137	47.9		0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
204	130	142	46.9		0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200

Required minimum cover:

"B" The vertical distance from a horizontal line across the widest part of the arch to inside crests of the corrugations of the lowest portion of the arch.

TABLE IIB
Sizes, Layout Details, and Wall Thicknesses (inches) for Corrugated Aluminum Alloy Structural Plate Pipe Arches for H-20 Loading

Span (in.)	Rise (in.)	Area (sq ft)	"B" (in.)	1.0*	1.5*	2.0*	2.5*	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
71	65	25	31.8	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
74	68	27	32.1	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
78	69	30	32.0	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
82	71	32	32.5	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
87	72	35	33.1	0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
91	74	37	33.9	0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
95	76	40	33.7	0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
98	77	42	32.3		0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
103	79	45	33.1		0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
106	81	48	32.6		0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
111	82	51	33.6		0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
116	84	54	34.6		0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
121	85	57	35.9		0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
125	87	60	35.3		0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
128	89	63	34.7		0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
132	91	66	34.0		0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
138	92	69	37.5		0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
140	94	73	34.6		0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
145	95	76	36.0		0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
149	97	80	35.2		0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
154	99	83	36.8		0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
157	100	87	35.9		0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
163	102	91	37.5		0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
168	103	94	39.4		0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
167	113	102	39.4		0.125	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
171	115	106	42.0		0.150	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
176	116	110	44.0		0.150	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
179	118	114	43.2		0.150	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
184	120	119	45.3		0.150	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
187	122	123	44.4		0.175	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
193	124	128	46.6		0.175	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
196	126	132	45.7		0.175	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
201	128	137	47.9		0.200	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
204	130	142	46.9		0.200	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100

* Required minimum cover.

"B" The vertical distance from a horizontal line across the widest part of the arch to inside crests of the corrugations of the lowest portion of the arch.

TABLE IIB (Metric)
 Sizes, Layout Details, and Wall Thicknesses (millimeters) for Corrugated Aluminum Alloy Structural Plate Pipe Arches for M 18 Loading

Span (mm)	Rise (mm)	Area (sq m)	"B" (mm)	0.3"	0.5"	0.6"	0.8"	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.3	3.7	4.0	4.3	4.6
1803	1651	2.3	808	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
1880	1727	2.5	815	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
1981	1753	2.8	813	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
2083	1803	3.0	826	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
2210	1829	3.3	841	3.18	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
2311	1880	3.4	861	3.18	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
2413	1930	3.7	856	3.18	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
2489	1956	3.9	820	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
2616	2007	4.2	841	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
2692	2057	4.5	828	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
2819	2083	4.7	853	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
2946	2134	5.0	879	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
3073	2159	5.3	912	3.18	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
3175	2210	5.6	897	3.18	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
3251	2261	5.9	881	3.18	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
3353	2311	6.1	864	3.18	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
3505	2337	6.4	953	3.18	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
3556	2388	6.8	879	3.18	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
3683	2413	7.1	914	3.18	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
3785	2464	7.4	894	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
3912	2515	7.7	935	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18
3988	2540	8.1	912	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18
4140	2591	8.5	953	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18
4267	2616	8.7	1001	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18
4242	2870	9.5	1001	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18
4343	2921	9.8	1067	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81
4470	2946	10.2	1118	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81
4547	2997	10.6	1097	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81
4674	3048	11.1	1151	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81
4750	3099	11.4	1128	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44
4902	3150	11.9	1184	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44
4978	3200	12.3	1161	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44
5105	3251	12.7	1217	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08
5192	3302	13.2	1191	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08

* Required minimum cover.

"B" The vertical distance from a horizontal line across the widest part of the arch to inside crests of the corrugations of the lowest portion of the arch.

541.04 Shipping and Storing. The loading, transporting, unloading, and storing of material shall be conducted so the steel and aluminum will be kept free from damage. Special care shall be taken to prevent disturbing the curvature in the plates. They shall be blocked to prevent damage during shipment and storage.

CONSTRUCTION REQUIREMENTS

541.05 Bearing Surfaces for Corrugated Structural Plate Arches. Each side of each arch shall be bolted to a steel bearing surface. Steel bearing surfaces shall be either structural steel channels or angles. The horizontal leg of the bearing surface shall be securely anchored to or embedded in the foundation and the vertical leg shall be punched to allow bolting to the bottom row of structural plates.

Channels shall be a minimum of 3/16 in. (5 mm) in thickness. Angles shall be a minimum of 3 x 3 x 1/4 in. (75 x 75 x 6 mm). Where the span of the arch is greater than 15 ft (4.5 m) or where the skew angle is more than 20 degrees, the steel bearing surface shall have a width at least equal to the depth of corrugation.

541.06 Erection and Backfill. The erection and backfill for corrugated structural plate drainage structures shall be according to the following.

- (a) Corrugated Structural Plate Pipe Culverts and Corrugated Structural Plate Pipe Arches. When a plate pipe structure is to be erected in a trench, the width of the trench shall be sufficient to permit thorough tamping of the earth backfill against every plate. The pipe shall be bedded on an earth foundation of uniform density shaped to fit the lower plate at the proper grade. Any soil below the foundation grade which has been disturbed by the Contractor's operations shall be removed. If the foundation excavation has been made deeper than necessary, the foundation shall be brought to proper grade by the addition of well-compacted fine aggregate.

Where a firm foundation is not encountered at the grade established, due to soft, spongy, or other unsuitable soil, all such unsuitable soil under the plate pipe structure and for a width of at least one diameter on each side of the structure, shall be removed and replaced with well compacted fine aggregate.

Where rock, in either ledge or boulder formation is encountered, it shall be removed and replaced with a cushion of well-compacted fine aggregate to a depth below the structure of not less than 1/2 in./ft (40 mm/m) of height of fill over the top of the structure, with a minimum thickness of 8 in. (200 mm).

All excavated material not needed on the work shall be disposed of according to Article 202.03.

When a corrugated structural plate pipe culvert or corrugated structural plate pipe arch has been completely erected in place, moist fine aggregate shall be placed alongside the structure in lifts not to exceed 8 in. (200 mm) in depth, loose measurement, and compacted for the full width of the trench, or so that on each side of the structure there shall be a berm of compacted or undisturbed soil at least as wide as the greatest external dimension of the

structure. The fine aggregate shall be placed longitudinally along the structure, except at the outer 3 ft (1 m) at each end of the structure, impervious material shall be used. The elevation of the backfill material on each side of the structure shall be the same. Special care shall be taken to compact the fine aggregate and impervious material under the haunches of the pipe. The backfill material, fine aggregate and impervious material shall be compacted to the satisfaction of the Engineer by mechanical means. This method of placement shall be continued until the top of the structure is covered with at least 1 ft (300 mm) of backfill material.

- (b) Corrugated Structural Plate Arches. Excavation for corrugated structural plate arches shall be according to the applicable provisions of Section 502.

When backfilling a structure before headwalls are placed, the first material shall be placed midway between the ends of the arch forming as narrow a ramp as possible until the top of the arch is reached. The ramp shall be built evenly from both sides, and the backfilling material shall be thoroughly compacted as it is placed. After the ramps have been built to the top of the arch, the remainder of the backfill shall be deposited from the top of the arch, both ways from the center to the ends, and as evenly as possible on both sides of the arch.

If the headwalls are built before the structure is backfilled, the filling material shall first be placed adjacent to one headwall until the top of the arch is reached, after which the fill shall be dumped from the top of the arch toward the other headwall, with care being taken to deposit the material evenly on both sides of the arch.

In multiple installations, the procedure specified above shall be followed, but extreme care shall be used to bring the backfill up evenly on each side of each arch so that unequal pressure will be avoided.

In all cases, the filling material shall be thoroughly but not excessively tamped. Puddling the backfill will not be permitted.

After the structure has been covered with 1 ft (300 mm) of backfill, additional embankment shall be constructed according to Article 542.04(h). The height of the additional embankment shall be that specified.

541.07 Workmanship. In addition to compliance with the required details of construction, the completed structural plate structure shall show careful, finished workmanship in all particulars. The following defects are specified as constituting poor workmanship and the presence of any or all of them in any individual plate or in any shipment shall be cause for rejection of the plate or shipment:

- (1) Uneven laps.
- (2) Elliptical shaping (unless specified).
- (3) Variation from a straight centerline.
- (4) Ragged edges.
- (5) Loose or unevenly lined or spaced bolts.
- (6) Bruised, scaled, or broken zinc coating.
- (7) Dents or bends in the metal.

541.08 Method of Measurement. Corrugated structural plate drainage structures of the types and sizes specified, or of a particular material when specified, will be measured for payment in place in feet (meters). Measurement will be from end to end along the flow line of pipes and along the bearing leg of structural plate arches.

Concrete will be measured for payment according to Article 503.21

Excavation for corrugated structural plate arches and rock excavation for all corrugated steel plate drainage structures will be measured for payment according to Article 502.12.

541.09 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for CORRUGATED STRUCTURAL PLATE PIPE CULVERTS, of the diameter specified; CORRUGATED STRUCTURAL PLATE PIPE ARCHES, of the area specified; and CORRUGATED STRUCTURAL PLATE ARCHES, of the area specified.

Concrete will be paid for according to Article 503.22

Excavation for corrugated structural plate arches and rock excavation for all corrugated steel plate drainage structures will be paid for according to Article 502.13.

The removal of unstable or unsuitable material or rock below foundation grade and the replacement thereof with the specified material, including additional excavation required to widen the trench, if required, will be paid for according to Article 109.04, unless the contract contains unit prices for the work included.

SECTION 542. PIPE CULVERTS

542.01 Description. This work shall consist of furnishing and installing pipe culverts.

542.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Corrugated Steel Pipe	1006.01
(b) Corrugated Steel Pipe Arch	1006.01
(c) Bituminous Coated Corrugated Steel Pipe	1006.01
(d) Bituminous Coated Corrugated Steel Pipe Arch	1006.01
(e) Zinc and Aramid Fiber Composite Coated Corrugated Steel Pipe	1006.01
(f) Aluminized Steel Type 2 Corrugated Pipe	1006.01
(g) Aluminized Steel Type 2 Corrugated Pipe Arch	1006.01
(h) Precoated Galvanized Corrugated Steel Pipe	1006.01
(i) Precoated Galvanized Corrugated Steel Pipe Arch	1006.01
(j) Corrugated Aluminum Alloy Pipe	1006.03
(k) Corrugated Aluminum Alloy Pipe Arch	1006.03
(l) Extra Strength Clay Pipe	1040.02
(m) Concrete Sewer, Storm Drain, and Culvert Pipe	1042
(n) Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe	1042
(o) Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe	1042
(p) Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe	1042
(q) Polyvinyl Chloride (PVC) Pipe	1040.03
(r) Corrugated Polyvinyl Chloride (PVC) Pipe with a Smooth Interior	1040.03
(s) Polyvinyl Chloride (PVC) Profile Wall Pipe-794	1040.03
(t) Polyvinyl Chloride (PVC) Profile Wall Pipe-304	1040.03
(u) Corrugated Polyethylene (PE) Pipe with a Smooth Interior	1040.04
(v) Polyethylene (PE) Profile Wall Pipe	1040.04
(w) Polyethylene (PE) Pipe with a Smooth Interior	1040.04
(x) Rubber Gaskets and Preformed Flexible Joint Sealants for Concrete Pipe	1056
(y) Mastic Joint Sealer for Pipe	1055
(z) External Sealing Band	1057
(aa) Fine Aggregate (Note 1)	1003.04
(bb) Coarse Aggregate (Note 2)	1004.05
(cc) Packaged Rapid Hardening Mortar or Concrete	1018
(dd) Nonshrink Grout	1024.02
(ee) Reinforcement Bars and Welded Wire Fabric	1006.10
(ff) Handling Hole Plugs	1042.16

Note 1. The fine aggregate shall be moist.

Note 2. The coarse aggregate shall be wet.

542.03 Material Permitted. When a Class of pipe is specified, the material shall be selected from the following table. When a particular material is specified, no other kind of material will be permitted.

Class	Materials
A	<p>Rigid Pipes:</p> <p>Extra Strength Clay Pipe</p> <p>Concrete Sewer Storm Drain and Culvert Pipe, Class 3</p> <p>Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe</p> <p>Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe</p> <p>Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe</p>
C	<p>Rigid Pipes:</p> <p>Extra Strength Clay Pipe</p> <p>Concrete Sewer Storm Drain and Culvert Pipe, Class 3</p> <p>Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe</p> <p>Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe</p> <p>Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe</p> <p>Flexible Pipes:</p> <p>Aluminized Steel Type 2 Corrugated Pipe</p> <p>Aluminized Steel Type 2 Corrugated Pipe Arch</p> <p>Precoated Galvanized Corrugated Steel Pipe</p> <p>Precoated Galvanized Corrugated Steel Pipe Arch</p> <p>Corrugated Aluminum Alloy Pipe</p> <p>Corrugated Aluminum Alloy Pipe Arch</p> <p>Polyvinyl Chloride (PVC) Pipe</p> <p>Corrugated Polyvinyl Chloride (PVC) Pipe with a Smooth Interior</p> <p>Polyvinyl Chloride (PVC) Profile Wall Pipe-794</p> <p>Polyvinyl Chloride (PVC) Profile Wall Pipe-304</p> <p>Polyethylene (PE) Profile Wall Pipe</p> <p>Polyethylene (PE) Pipe with a Smooth Interior</p>
D	<p>Rigid Pipes:</p> <p>Extra Strength Clay Pipe</p> <p>Concrete Sewer Storm Drain and Culvert Pipe, Class 3</p> <p>Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe</p> <p>Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe</p> <p>Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe</p> <p>Flexible Pipes:</p> <p>Corrugated Steel Pipe</p> <p>Corrugated Steel Pipe Arch</p> <p>Bituminous Coated Corrugated Steel Pipe</p> <p>Bituminous Coated Corrugated Steel Pipe Arch</p> <p>Zinc and Aramid Fiber Composite Coated Corrugated Steel Pipe</p> <p>Aluminized Steel Type 2 Corrugated Pipe</p> <p>Aluminized Steel Type 2 Corrugated Pipe Arch</p> <p>Precoated Galvanized Corrugated Steel Pipe</p> <p>Precoated Galvanized Corrugated Steel Pipe Arch</p> <p>Corrugated Aluminum Alloy Pipe</p> <p>Corrugated Aluminum Alloy Pipe Arch</p> <p>Polyvinyl Chloride (PVC) Pipe</p> <p>Corrugated Polyvinyl Chloride (PVC) Pipe with a Smooth Interior</p> <p>Polyvinyl Chloride (PVC) Profile Wall Pipe-794</p> <p>Polyvinyl Chloride (PVC) Profile Wall Pipe-304</p> <p>Corrugated Polyethylene (PE) Pipe with a Smooth Interior</p> <p>Polyethylene (PE) Profile Wall Pipe</p> <p>Polyethylene (PE) Pipe with a Smooth Interior</p>

When metric sizes are specified on the plans, the next larger available manufactured English pipe may be substituted at no additional cost to the Department.

For PE pipe culverts, where no end treatment is specified, a standard corrugated PE coupling shall be provided for each exposed end of the pipe. The coupling shall be installed flush with the end(s) of the pipe.

The Contractor may, at no additional cost to the Department, substitute a stronger pipe of the same kind of material specified.

When a pipe diameter is specified, only a circular pipe will be permitted. When a round size equivalent is specified, only elliptical or arch pipe will be permitted.

The kind of material and thickness or thickness class required for the various types of pipe culverts shall be according to Tables IA - IC, IIA, IIB, and IIIA – IIIC and the following.

- (a) Steel or aluminum alloy arch and concrete elliptical or arch pipes will be designated pipe culverts, special for fill heights exceeding 15 ft (4.5 m).
- (b) Extra strength clay pipe will only be permitted for pipe culverts Types 2 and 3, up to and including 36 in. (900 mm), for all pipe classes.
- (c) Concrete sewer, storm drain, and culvert pipe Class 3 will only be permitted for pipe culverts Type 2, up to and including 36 in. (900 mm); and pipe culverts Type 3, up to and including 24 in. (600 mm), for all pipe classes.

TABLE 1A: CLASSES OF REINFORCED CONCRETE PIPE
FOR THE RESPECTIVE DIAMETERS OF PIPE AND FILL HEIGHTS OVER THE TOP OF PIPE

Nominal Diameter in.	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7
	Fill Height: 3' and less 1' min. cover	Fill Height: Greater than 3' not exceeding 10'	Fill Height: Greater than 10' not exceeding 15'	Fill Height: Greater than 15' not exceeding 20'	Fill Height: Greater than 20' not exceeding 25'	Fill Height: Greater than 25' not exceeding 30'	Fill Height: Greater than 30' not exceeding 35'
12	IV	II	III	IV	V	V	V
15	IV	II	III	IV	V	V	V
18	IV	II	III	IV	V	V	V
21	IV	II	III	IV	IV	V	V
24	IV	II	III	IV	IV	V	V
30	IV	II	III	IV	IV	V	V
36	III	II	III	IV	IV	V	V
42	III	II	III	IV	IV	V	V
48	II	II	III	IV	IV	V	V
54	II	II	III	IV	IV	V	V
60	I	I	III	IV	V	V	V
66	I	I	III	IV	V	V	V
72	I	I	III	IV	V	V	V
78	I	I	III	IV	*V	*V	*V
84	I	I	III	IV	*V	*V	*V
90	I	I	III	*IV	*V	*V	*V
96	I	I	III	*IV	*V	*V	*V
102	I	I	III	*IV	*V	*V	*V
108	I	I	III	*IV	*V	*V	*V

* Special Design Required

TABLE 1A: CLASSES OF REINFORCED CONCRETE PIPE
FOR THE RESPECTIVE DIAMETERS OF PIPE AND FILL HEIGHTS OVER THE TOP OF PIPE
(Metric)

Nominal Diameter mm	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7
	Fill Height: 1 m and less 0.3 m min. cover	Fill Height: Greater than 1 m not exceeding 3 m	Fill Height: Greater than 3 m not exceeding 4.5 m	Fill Height: Greater than 4.5 m not exceeding 6 m	Fill Height: Greater than 6 m not exceeding 7.5 m	Fill Height: Greater than 7.5 m not exceeding 9 m	Fill Height: Greater than 9 m not exceeding 10.5 m
300	IV	II	III	IV	V	V	V
375	IV	II	III	IV	V	V	V
450	IV	II	III	IV	IV	V	V
525	IV	II	III	IV	IV	V	V
600	IV	II	III	IV	IV	V	V
750	IV	II	III	IV	IV	V	V
900	III	II	III	IV	IV	V	V
1050	III	II	III	IV	IV	V	V
1200	II	II	III	IV	IV	V	V
1350	II	II	III	IV	IV	V	V
1500	I	I	III	IV	V	V	V
1650	I	I	III	IV	V	V	V
1800	I	I	III	IV	V	V	V
1950	I	I	III	IV	*V	*V	*V
2100	I	I	III	IV	*V	*V	*V
2250	I	I	III	*IV	*V	*V	*V
2400	I	I	III	*IV	*V	*V	*V
2550	I	I	III	*IV	*V	*V	*V
2700	I	I	III	*IV	*V	*V	*V

* Special Design Required

TABLE IB: THICKNESS OF CORRUGATED STEEL PIPE FOR THE RESPECTIVE DIAMETER OF PIPE AND FILL HEIGHTS OVER THE TOP OF PIPE FOR 2 2/3" x 1/2" AND 3" x 1" CORRUGATIONS

Nominal Diameter in.	Type 1		Type 2		Type 3		Type 4		Type 5		Type 6		Type 7	
	Fill Height:	3' and less 1' min. cover	Fill Height:	Greater than 3' not exceeding 10'	Fill Height:	Greater than 10' not exceeding 15'	Fill Height:	Greater than 15' not exceeding 20'	Fill Height:	Greater than 20' not exceeding 25'	Fill Height:	Greater than 25' not exceeding 30'	Fill Height:	Greater than 30' not exceeding 35'
10	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"
12	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064
15	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064
18	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064
21	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064
24	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079
30	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079
36	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079
42	0.109	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079
48	0.109	0.109	0.079	0.079	0.109	0.079	0.109	0.079	0.109	0.079	0.109	0.079	0.109	0.079
54	0.109	0.109	0.109	0.079	0.109	0.079	0.109	0.079	0.109	0.079	0.109	0.079	0.109	0.079
60	0.138	0.109	0.109	0.079	0.109	0.079	0.109	0.079	0.138	0.109	0.138	0.109	0.138	0.109
66	0.138	0.109	0.138	0.079	0.138	0.079	0.138	0.079	0.138	0.109	0.138	0.109	0.138	0.109
72	0.138Z	0.109	0.138	0.079	0.138	0.079	0.138	0.079	0.138	0.109	0.138	0.109	0.138	0.109
78	0.168Z	0.109	0.168	0.079	0.168	0.079	0.168	0.079	0.168	0.109	0.168	0.109	0.168	0.109
84	0.168Z	0.109	0.168	0.079	0.168	0.079	0.168	0.079	0.168	0.109	0.168	0.109	0.168	0.109
90	NB	0.109	NB	0.109	NB	0.109	NB	0.109	NB	0.109	NB	0.109	NB	0.109
96	NB	0.109	NB	0.109	NB	0.109	NB	0.109	NB	0.109	NB	0.109	NB	0.109
102	NB	0.109Z	NB	0.109	NB	0.109	NB	0.109	NB	0.109	NB	0.109	NB	0.109
108	NB	0.109Z	NB	0.109	NB	0.109	NB	0.109	NB	0.109	NB	0.109	NB	0.109
114	0.138Z	0.109	0.138Z	0.109	0.138	0.109	0.138	0.109	0.138	0.109	0.138	0.109	0.138	0.109
120	0.138Z	0.109	0.138Z	0.109	0.138	0.109	0.138	0.109	0.138	0.109	0.138	0.109	0.138	0.109
126	0.138Z	0.109	0.138Z	0.109	0.138	0.109	0.138	0.109	0.138	0.109	0.138	0.109	0.138	0.109
132	0.168Z	0.138	0.168Z	0.138	0.168	0.138	0.168	0.138	0.168	0.138	0.168	0.138	0.168	0.138
138	0.168Z	0.138	0.168Z	0.138	0.168	0.138	0.168	0.138	0.168	0.138	0.168	0.138	0.168	0.138
144	0.168Z	0.138	0.168Z	0.138	0.168	0.138	0.168	0.138	0.168	0.138	0.168	0.138	0.168	0.138

Note: 5" x 1" corrugations may be used in lieu of 3"x1" corrugations
** 1 1/2" x 1/4" corrugations shall be used in lieu of 2 2/3" x 1/2" for 6", 8", and 10" diameters
E Elongate according to Article 542.04(e)
NB Use uncoated corrugated steel structural plate pipe according to Section 541
Z 1'-6" minimum fill

TABLE 1B: THICKNESS OF CORRUGATED STEEL PIPE
FOR THE RESPECTIVE DIAMETER OF PIPE AND FILL HEIGHTS OVER THE TOP OF PIPE FOR 68 mm x 13 mm AND 75 mm x 25 mm CORRUGATIONS
(Metric)

Nominal Diameter mm	Type 1		Type 2		Type 3		Type 4		Type 5		Type 6		Type 7	
	Fill Height: 1 m and less 0.3 m min. cover		Fill Height: Greater than 1 m not exceeding 3 m		Fill Height: Greater than 3 m not exceeding 4.5 m		Fill Height: Greater than 4.5 m not exceeding 6 m		Fill Height: Greater than 6 m not exceeding 7.5 m		Fill Height: Greater than 7.5 m not exceeding 9 m		Fill Height: Greater than 9 m not exceeding 10.5 m	
	68 mm x 13 mm	75 mm x 25 mm	68 mm x 13 mm	75 mm x 25 mm	68 mm x 13 mm	75 mm x 25 mm	68 mm x 13 mm	75 mm x 25 mm	68 mm x 13 mm	75 mm x 25 mm	68 mm x 13 mm	75 mm x 25 mm	68 mm x 13 mm	75 mm x 25 mm
**250	1.63		1.63		1.63		1.63		1.63		1.63		1.63	
300	1.63		1.63		1.63		1.63		1.63		1.63		1.63	
400	1.63		1.63		1.63		1.63		1.63		1.63		1.63	
450	1.63		1.63		1.63		1.63		1.63		1.63		1.63	
500	1.63		1.63		1.63		1.63		1.63		1.63		1.63	
600	2.01		2.01		2.01		2.01		2.01		2.01		2.77	
700	2.01		2.01		2.01		2.01		2.01		2.77		3.51	
800	2.01		2.01		2.01		2.01		2.77		3.51		4.27	
900	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.77	2.01	3.51	2.77	4.27	2.77
1000	2.77	2.01	2.01	2.01	2.01	2.01	2.77	2.01	2.77	2.01	4.27	2.77	2.77E	2.77
1200	2.77	2.77	2.01	2.01	2.77	2.01	2.77	2.77	3.51	2.77	2.77E	2.77	3.51E	2.77
1400	2.77	2.77	2.77	2.01	2.77	2.01	2.77	2.77	4.27	2.77	3.51E	2.77	3.51E	3.51E
1600	3.51	2.77	3.51	2.01	3.51	2.77	3.51	2.77	4.27E	2.77	4.27E	3.51E	NB	3.51E
1800	3.51Z	2.77	3.51	2.01	3.51	2.77	4.27	2.77	NB	2.77	NB	3.51E	NB	3.51E
2000	4.27Z	2.77	4.27	2.01	4.27	2.77	NB	2.77	NB	3.51	NB	3.51E	NB	3.51E
2200	4.27Z	2.77	4.27	2.77	4.27	2.77	NB	2.77	NB	3.51E	NB	3.51E	NB	3.51E
2400	NB	2.77	NB	2.77	NB	2.77	NB	3.51	NB	3.51E	NB	3.51E	NB	4.27E
2700	NB	2.77Z	NB	2.77	NB	3.51	NB	3.51	NB	4.27E	NB	4.27E	NB	NB
3000		3.51Z		2.77		3.51		4.27	NB	NB	NB	NB	NB	NB
3300		4.27Z		3.51		4.27		NB	NB	NB	NB	NB	NB	NB
3600		4.27Z		3.51		NB		NB	NB	NB	NB	NB	NB	NB

Note: 125 mm x 25 mm corrugations may be used in lieu of 75 mm x 25 mm corrugations
 ** 38 mm x 6.5 mm corrugations shall be used in lieu of 68 mm x 13 mm for 150 mm, 200 mm, and 250 mm diameters
 E Elongate according to Article 542.04(e)
 NB Use uncoated corrugated steel structural plate pipe according to Section 541
 Z 450 mm minimum fill

TABLE IC: THICKNESS OF CORRUGATED ALUMINUM ALLOY PIPE FOR RESPECTIVE DIAMETER OF PIPE AND FILL HEIGHTS OVER THE TOP OF PIPE FOR 2 2/3" x 1/2" AND 3" x 1" CORRUGATIONS														
Nominal Diameter in.	Type 1		Type 2		Type 3		Type 4		Type 5		Type 6		Type 7	
	Fill Height: 3' and less 1' min. cover		Fill Height: Greater than 3' not exceeding 10'		Fill Height: Greater than 10' not exceeding 15'		Fill Height: Greater than 15' not exceeding 20'		Fill Height: Greater than 20' not exceeding 25'		Fill Height: Greater than 25' not exceeding 30'		Fill Height: Greater than 30' not exceeding 35'	
10	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"
12	0.060		0.060		0.060		0.060		0.060		0.060		0.060	
15	0.060		0.060		0.060		0.060		0.060		0.060		0.060	
18	0.060		0.060		0.060		0.060		0.060		0.060		0.105	
21	0.060		0.060		0.060		0.060		0.060		0.105		0.135	
24	0.075		0.075		0.075		0.075		0.105		0.105		0.164	
30	0.105	0.105	0.075	0.075	0.105	0.075	0.105	0.105	0.105	0.105	0.135E	0.105	0.105E	X
36	0.105	0.105	0.105	0.075	0.105	0.075	0.105	0.105	0.164	0.135E	0.135E	0.135	0.135E	X
42	0.135	0.105	0.105	0.075	0.105	0.075	0.135	0.105	0.135E	0.105	0.164E	0.135	0.164E	X
48	0.135	0.105	0.105	0.075	0.135	0.105	0.164	0.105	0.164E	0.105	X	X	X	X
54	0.164	0.105	0.135	0.075	0.164	0.105	X	0.105	X	0.135	X	X	X	X
60	0.164Z	0.105	0.135	0.105	X	0.105	X	0.105	X	X	X	X	X	X
66	X	0.105	0.164	0.105	X	0.105	X	0.105	X	X	X	X	X	X
72	X	0.135	X	0.105	X	0.105	X	0.135	X	X	X	X	X	X
78	X	0.135	X	0.105	X	0.135	X	0.135	X	X	X	X	X	X
84	X	0.164	X	0.105	X	0.135	X	0.164	X	X	X	X	X	X
90	X	0.164	X	0.135	X	0.164	X	X	X	X	X	X	X	X
96	X	X	X	0.135	X	0.164	X	X	X	X	X	X	X	X
102	X	X	X	0.164	X	X	X	X	X	X	X	X	X	X
108	X	X	X	0.164	X	X	X	X	X	X	X	X	X	X
114	X	X	X	0.164	X	X	X	X	X	X	X	X	X	X
120	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Note:

- E Elongate according to Article 542.04(e)
- X Use either steel or concrete pipe
- Z 1'-6" minimum fill

TABLE IC: THICKNESS OF CORRUGATED ALUMINUM ALLOY PIPE
FOR RESPECTIVE DIAMETER OF PIPE AND FILL HEIGHTS OVER THE TOP OF PIPE FOR 68 mm x 13 mm AND 75 mm x 25 mm CORRUGATIONS
(Metric)

Nominal Diameter mm	Type 1		Type 2		Type 3		Type 4		Type 5		Type 6		Type 7	
	Fill Height: 1 m and less 0.3 m min. cover		Fill Height: Greater than 1 m not exceeding 3 m		Fill Height: Greater than 3 m not exceeding 4.5 m		Fill Height: Greater than 4.5 m not exceeding 6 m		Fill Height: Greater than 6 m not exceeding 7.5 m		Fill Height: Greater than 7.5 m not exceeding 9 m		Fill Height: Greater than 9 m not exceeding 10.5 m	
250	68 mm x 13 mm	75 mm x 25 mm	68 mm x 13 mm	75 mm x 25 mm	68 mm x 13 mm	75 mm x 25 mm	68 mm x 13 mm	75 mm x 25 mm	68 mm x 13 mm	75 mm x 25 mm	68 mm x 13 mm	75 mm x 25 mm	68 mm x 13 mm	75 mm x 25 mm
300	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52
400	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52
450	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52
500	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52
600	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91
700	2.67	2.67	1.91	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67
800	2.67	2.67	2.67	2.67	1.91	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67
900	2.67	2.67	2.67	2.67	1.91	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67
1000	3.43	2.67	2.67	2.67	1.91	2.67	3.43	2.67	3.43E	2.67	3.43	2.67	3.43	2.67
1200	3.43	2.67	2.67	2.67	1.91	2.67	3.43	2.67	3.43E	2.67	3.43	2.67	3.43	2.67
1400	4.17	2.67	3.43	1.91	2.67	4.17	4.17	2.67	4.17E	2.67	4.17	2.67	4.17	2.67
1600	X	2.67	4.17	2.67	X	2.67	X	2.67	X	3.43	X	X	X	X
1800	X	3.43	X	2.67	X	2.67	X	3.43	X	X	X	X	X	X
2000	X	3.43	X	2.67	X	3.43	X	3.43	X	X	X	X	X	X
2200	X	4.17	X	2.67	X	4.17	X	4.17	X	X	X	X	X	X
2400	X	X	X	3.43	X	4.17	X	X	X	X	X	X	X	X
2700	X	X	X	4.17	X	X	X	X	X	X	X	X	X	X
3000	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Note:

E Elongate according to Article 542.04(e)

X Use either steel or concrete pipe

Z 450 mm minimum fill

TABLE IIA: THICKNESS FOR CORRUGATED STEEL PIPE ARCHES AND CORRUGATED ALUMINUM ALLOY PIPE ARCHES FOR THE RESPECTIVE EQUIVALENT ROUND SIZE OF PIPE AND FILL HEIGHTS OVER THE TOP OF PIPE														
Equivalent Round Size in.	Corrugated Steel Pipe Arch 2 2/3"x1/2"				Corrugated Aluminum Pipe Arch 2 2/3"x1/2"				Type 1 Fill Height: 3' and less			Type 2 Fill Height: Greater than 3' not Exceeding 10'		
	Span		Rise		Span		Rise		Min. Cover	Steel & Alum	Type 1		Type 2	
	in.	in.	in.	in.	in.	in.	in.	in.			Steel	Aluminum	Steel	Aluminum
15	17	13	13	13	17	13	13	13	1'-0"	1'-0"	2 2/3 x 1/2 in.	2 2/3 x 1/2 in.	2 2/3 x 1/2 in.	2 2/3 x 1/2 in.
18	21	15	15	15	21	15	15	15	1'-0"	1'-0"	0.064	0.064	0.064	0.060
21	24	18	18	18	24	18	18	18	1'-0"	1'-0"	0.064	0.064	0.064	0.060
24	28	20	20	20	28	20	20	20	1'-6"	1'-6"	0.079	0.075	0.079	0.075
30	35	24	24	24	35	24	24	24	1'-6"	1'-6"	0.079	0.105	0.079	0.105
36	42	29	29	29	42	29	29	29	1'-6"	1'-6"	0.079	0.105	0.079	0.105
42	49	33	33	33	49	33	33	33	1'-6"	1'-6"	0.109	0.135	0.109	0.135
48	57	38	38	38	57	38	38	38	1'-6"	1'-6"	0.109	0.164	0.109	0.164
54	64	43	43	43	64	43	43	43	1'-6"	1'-6"	0.109	X	0.109	X
60	71	47	47	47	71	47	47	47	1'-6"	1'-6"	0.138	X	0.138	X
66	77	52	52	52	77	52	52	52	1'-6"	1'-6"	0.168	X	0.168	X
72	83	57	57	57	83	57	57	57	1'-6"	1'-6"	0.168	X	0.168	X
78	87	63	63	63	87	63	63	63	1'-6"	1'-6"	0.109	0.109	0.109	0.109
84	95	67	67	67	95	67	67	67	1'-6"	1'-6"	0.109	0.109	0.109	0.109
90	103	71	71	71	103	71	71	71	1'-6"	1'-6"	0.109	0.109	0.109	0.109
96	112	75	75	75	112	75	75	75	1'-6"	1'-6"	0.138	0.138	0.138	0.138
102	117	79	79	79	117	79	79	79	1'-6"	1'-6"	0.138	0.138	0.138	0.138
108	128	83	83	83	128	83	83	83	1'-6"	1'-6"	0.138	0.138	0.138	0.168
114	137	87	87	87	137	87	87	87	1'-6"	1'-6"	0.168	0.138	0.168	0.168
120	142	91	91	91	142	91	91	91	1'-6"	1'-6"	0.168	0.138	0.168	0.168

NOTES: The Type 1 and 3 corrugated steel or aluminum pipe arches shall be placed on soil having a minimum bearing capacity of 3 tons per square foot. The Type 2 corrugated steel or aluminum pipe arches shall be placed on soil having a minimum bearing capacity of 2 tons per square foot. This minimum bearing capacity will be determined by the Engineer in the field.

The 125 mm x 25 mm metric corrugations for Corrugated Steel Pipe Arch may be used in lieu of the 3" x 1" corrugations.

X Use either steel or concrete.

**TABLE - IIA: THICKNESS FOR CORRUGATED STEEL PIPE ARCHES AND CORRUGATED ALUMINUM ALLOY PIPE ARCHES
FOR THE RESPECTIVE EQUIVALENT ROUND SIZE OF PIPE AND FILL HEIGHTS OVER THE TOP OF PIPE
(Metric)**

Equivalent Round Size mm	Type 1				Type 2				Type 3	
	Fill Height:				Fill Height:				Fill Height:	
	1 m and less				Greater than 1 m not Exceeding 3 m				Greater than 3 m not Exceeding 4.5 m	
Corrugated Steel Pipe Arch 68 x 13 mm	Corrugated Steel Pipe Arch 75 x 25 mm		Corrugated Aluminum Pipe Arch 68 x 13 mm		Min. Cover	Steel		Aluminum		Aluminum
	Span mm	Rise mm	Span mm	Rise mm		68 x 13 mm	75 x 25 mm	68 x 13 mm	75 x 25 mm	
400	460	340	460	340	0.3 m	1.63		1.52		68 x 13 mm
450	510	380	510	380	0.3 m	1.63		1.52		1.52
500	560	420	560	420	0.3 m	1.63		1.52		1.52
600	680	500	680	500	0.5 m	2.01		1.91		1.91
700	800	580	800	580	0.5 m	2.01		2.67		2.67
800	910	660	910	660	0.5 m	2.01		2.67		2.67
900	1030	740	1030	740	0.5 m	2.01		2.67		2.67
1000	1150	820	1150	820	0.5 m	2.77	2.01	3.43	2.01	3.43
1200	1390	970	1330	1030	0.5 m	2.77	2.01	4.17	2.77	4.17
1400	1630	1120	1550	1200	0.5 m	2.77	2.01	4.17	2.77	4.17
1600	1880	1260	1780	1360	0.5 m	4.27	2.77	X	4.27	X
1800	2130	1400	2010	1500	0.5 m	4.27	2.77	X	4.27	X
2000			2230	1700	0.5 m		2.77		2.77	
2200			2500	1830	0.5 m		2.77		2.77	
2400			2800	1950	0.5 m		3.51		3.51	
2700			3300	2080	0.5 m		3.51		4.27	
3000			3650	2280	0.5 m		4.27		4.27	

NOTES: The Type 1 and 3 corrugated steel or aluminum pipe arches shall be placed on soil having a minimum bearing capacity of 290 kN/sq m. The Type 2 corrugated steel or aluminum pipe arches shall be placed on soil having a minimum bearing capacity of 192 kN/sq m. This minimum bearing capacity will be determined by the Engineer in the field.

X Use either steel or concrete.

TABLE IIB: CLASSES OF REINFORCED CONCRETE ELLIPTICAL AND REINFORCED CONCRETE ARCH PIPE FOR THE RESPECTIVE EQUIVALENT ROUND SIZE OF PIPE AND FILL HEIGHTS OVER THE TOP OF PIPE											
Equivalent Round Size in.	Reinforced Concrete Elliptical Pipe in.			Reinforced Concrete Arch Pipe in.		Min. Cover	Type 1		Type 2		Type 3
	Span	Rise		Span	Rise		Fill Height: 3' and less	Arch	Fill Height: Greater than 3' not Exceeding 10'	Arch	Fill Height: Greater than 10' not Exceeding 15'
15	23	14		18	11	RCCP HE & A	HE	Arch	HE	Arch	HE
18	23	14		22	13 1/2	1'-3"	HE-IV	A-IV	HE-I	A-II	HE-III
21	30	19		26	15 1/2	1'-3"	HE-IV	A-IV	HE-I	A-II	HE-III
24	30	19		28 1/2	18	1'-0"	HE-IV	A-IV	HE-I	A-II	HE-III
27	34	22		36 1/4	22 1/2	1'-0"	HE-III	A-III	HE-I	A-II	HE-III
30	38	24		36 1/4	22 1/2	1'-0"	HE-III	A-III	HE-I	A-II	HE-III
36	45	29		43 3/4	26 5/8	1'-0"	HE-III	A-III	HE-I	A-II	HE-III
42	53	34		51 1/8	31 5/16	1'-0"	HE-II	A-II	HE-I	A-II	HE-III
48	60	38		58 1/2	36	1'-0"	HE-II	A-II	HE-I	A-II	HE-III
54	68	43		65	40	1'-0"	HE-I	A-II	HE-I	A-II	HE-III
60	76	48		73	45	1'-0"	HE-I	A-II	HE-I	A-II	HE-III
66	83	53		88	54	1'-0"	HE-I	A-II	HE-I	A-II	HE-III
72	91	58		88	54	1'-0"	HE-I	A-II	HE-I	A-II	HE-III

TABLE IIB: CLASSES OF REINFORCED CONCRETE ELLIPTICAL AND REINFORCED CONCRETE ARCH PIPE FOR THE RESPECTIVE EQUIVALENT ROUND SIZE OF PIPE AND FILL HEIGHTS OVER THE TOP OF PIPE (Metric)										
Equivalent Round Size mm	Reinforced Concrete Elliptical Pipe mm		Reinforced Concrete Arch Pipe mm		Min. Cover	Type 1		Type 2		Type 3
						Fill Height: 1 m and less	HE	HE	Arch	Fill Height: Greater than 3 m not Exceeding 4.5 m
	Span	Rise	Span	Rise	RCCP HE & A	Arch	HE	HE	Arch	HE
375	584	356	457	279	0.4 m	A-IV	HE-IV	HE-I	A-II	HE-III
450	584	356	559	343	0.4 m	A-IV	HE-IV	HE-I	A-II	HE-III
525	762	483	660	394	0.3 m	A-IV	HE-IV	HE-I	A-II	HE-III
600	762	483	724	457	0.3 m	A-IV	HE-IV	HE-I	A-II	HE-III
686	864	559	921	572	0.3 m	A-III	HE-III	HE-I	A-II	HE-III
750	965	610	921	572	0.3 m	A-III	HE-III	HE-I	A-II	HE-III
900	1143	737	1111	676	0.3 m	A-III	HE-III	HE-I	A-II	HE-III
1050	1346	864	1299	795	0.3 m	A-II	HE-II	HE-I	A-II	HE-III
1200	1524	965	1486	914	0.3 m	A-II	HE-II	HE-I	A-II	HE-III
1350	1727	1092	1651	1016	0.3 m	A-II	HE-I	HE-I	A-II	HE-III
1500	1930	1219	1854	1143	0.3 m	A-II	HE-I	HE-I	A-II	HE-III
1676	2108	1346	2235	1372	0.3 m	A-II	HE-I	HE-I	A-II	HE-III
1800	2311	1473	2235	1372	0.3 m	A-II	HE-I	HE-I	A-II	HE-III

TABLE IIIA: PLASTIC PIPE PERMITTED
FOR A GIVEN PIPE DIAMETER AND FILL HEIGHT OVER THE TOP OF THE PIPE

Nominal Diameter in.	Type 1						Type 2					
	Fill Height: 3' and less, with 1' min. cover						Fill Height: Greater than 3', not exceeding 10'					
	PVC	CPVC	PVCPW -794	PVCPW -304	PE	CPE	PVC	CPVC	PVCPW -794	PVCPW -304	PE	CPE
10	X	NA	NA	NA	X	NA	X	*	NA	NA	X	NA
12	X	X	X	X	X	NA	X	X	X	X	X	X
15	X	X	X	X	X	X	X	X	X	X	X	X
18	X	X	X	X	X	X	X	X	X	X	X	X
21	X	X	X	X	NA	NA	X	X	X	X	NA	NA
24	X	X	X	X	X	X	X	X	X	X	X	X
30	X	X	X	X	X	X	X	X	X	X	X	X
36	X	X	X	X	X	X	X	X	X	X	X	X
42	NA	NA	X	X	X	X	NA	NA	X	X	X	X
48	NA	NA	X	X	X	X	NA	NA	X	X	X	X

TABLE IIIB: PLASTIC PIPE PERMITTED
FOR A GIVEN PIPE DIAMETER AND FILL HEIGHT OVER THE TOP OF THE PIPE

Nominal Diameter in.	Type 3						Type 4					
	Fill Height: Greater than 10', not exceeding 15'						Fill Height: Greater than 15', not exceeding 20'					
	PVC	CPVC	PVCPW -794	PVCPW -304	PE	PEPW	PVC	CPVC	PVCPW -794	PVCPW -304		
10	X	*	NA	NA	X	NA	X	*	NA	NA		
12	X	X	X	X	X	NA	X	X	X	X		
15	X	X	X	X	X	NA	X	X	X	X		
18	X	X	X	X	X	X	X	X	X	X		
21	X	X	X	X	NA	X	X	X	X	X		
24	X	X	X	X	X	X	X	X	X	X		
30	X	X	X	X	X	X	X	X	X	X		
36	X	X	X	X	X	X	X	X	X	X		
42	NA	NA	X	X	X	X	NA	NA	X	X		
48	NA	NA	X	X	X	X	NA	NA	X	X		

PVC Polyvinyl Chloride (PVC) Pipe
CPVC Corrugated Polyvinyl Chloride (PVC) Pipe with a Smooth Interior
PVCPW-794 Polyvinyl Chloride (PVC) Profile Wall Pipe-794
PVCPW-304 Polyvinyl Chloride (PVC) Profile Wall Pipe-304
X This material may be used for the given pipe diameter and fill height.
NA This material is Not Acceptable for the given pipe diameter and fill height.
* May be used if Bureau of Materials and Physical Research approves and with manufacturer's certification.

PE Polyethylene (PE) Pipe with a Smooth Interior
CPE Corrugated Polyethylene (PE) Pipe with a Smooth Interior
PEPW Polyethylene (PE) Profile Wall Pipe

TABLE IIIC: PLASTIC PIPE PERMITTED FOR A GIVEN PIPE DIAMETER AND FILL HEIGHT OVER THE TOP OF THE PIPE									
Nominal Diameter in.	Type 5 Fill Height: Greater Than 20', not exceeding 25'				Type 6 Fill Height: Greater than 25', not exceeding 30'				Type 7 Fill Height: Greater than 30', not exceeding 35'
	PVC	CPVC	PVC/PW -794	PVC/PW -304	PVC	CPVC	PVC/PW -794	PVC/PW -304	PVC
10	X	*	NA	NA	X	*	NA	NA	X
12	X	X	X	X	X	X	X	X	X
15	X	X	X	X	X	NA	NA	NA	X
18	X	X	X	X	X	NA	NA	NA	X
21	X	X	X	X	X	NA	NA	NA	X
24	X	X	X	X	X	NA	NA	NA	X
30	X	NA	NA	NA	X	NA	NA	NA	X
36	X	NA	NA	NA	X	NA	NA	NA	X
42	NA	NA	NA	NA	NA	NA	NA	NA	NA
48	NA	NA	NA	NA	NA	NA	NA	NA	NA

PVC Polyvinyl Chloride (PVC) Pipe
 CPVC Corrugated Polyvinyl Chloride (PVC) Pipe With a Smooth Interior
 PVC/PW-794 Polyvinyl Chloride (PVC) Profile Wall Pipe-794
 PVC/PW-304 Polyvinyl Chloride (PVC) Profile Wall Pipe-304
 X This material may be used for the given pipe diameter and fill height.
 NA This material is Not Acceptable for the given pipe diameter and fill height.
 * May be used if Bureau of Materials and Physical Research approves and with manufacturers' certification.

TABLE IIIA: PLASTIC PIPE PERMITTED
FOR A GIVEN PIPE DIAMETER AND FILL HEIGHT OVER THE TOP OF THE PIPE
(Metric)

Nominal Diameter mm	Type 1 Fill Height: 1 m and less with 0.3 m min. cover					Type 2 Fill Height: Greater than 1 m, not exceeding 3 m				
	PVC	CPVC	PVCPW -794	PVCPW -304	PE	CPE	PEPW	PVC	CPVC	PE
250	X	NA	NA	NA	X	NA	NA	X	*	X
300	X	X	X	X	X	X	NA	X	X	X
375	X	X	X	X	X	X	NA	X	X	X
450	X	X	X	X	X	X	NA	X	X	X
525	X	X	X	X	NA	NA	X	X	X	NA
600	X	X	X	X	X	X	X	X	X	X
750	X	X	X	X	X	X	X	X	X	X
900	X	X	X	X	X	X	X	X	X	X
1000	NA	NA	X	X	X	X	X	NA	NA	X
1200	NA	NA	X	X	X	X	X	NA	NA	X

TABLE IIIB: PLASTIC PIPE PERMITTED
FOR A GIVEN PIPE DIAMETER AND FILL HEIGHT OVER THE TOP OF THE PIPE
(Metric)

Nominal Diameter mm	Type 3 Fill Height: Greater than 3 m, not exceeding 4.5 m					Type 4 Fill Height: Greater than 4.5 m, not exceeding 6 m				
	PVC	CPVC	PVCPW -794	PVCPW -304	PE	PEPW	PVC	CPVC	PVCPW -794	PVCPW -304
250	X	*	NA	NA	X	NA	X	*	NA	NA
300	X	X	X	X	X	NA	X	X	X	X
375	X	X	X	X	X	NA	X	X	X	X
450	X	X	X	X	X	X	X	X	X	X
525	X	X	X	X	NA	X	X	X	X	X
600	X	X	X	X	X	X	X	X	X	X
750	X	X	X	X	X	X	X	X	X	X
900	X	X	X	X	X	X	X	X	X	X
1000	NA	NA	X	X	X	X	NA	NA	X	X
1200	NA	NA	X	X	X	X	NA	NA	X	X

CPVC Corrugated Polyvinyl Chloride (PVC) Pipe with a Smooth Interior
PVCPW-794 Polyvinyl Chloride (PVC) Profile Wall Pipe-794
PVCPW-304 Polyvinyl Chloride (PVC) Profile Wall Pipe-304
X This material may be used for the given pipe diameter and fill height.
* This material is Not Acceptable for the given pipe diameter and fill height.
May be used if Bureau of Materials and Physical Research approves and with manufacturer's certification.

PVC Polyvinyl Chloride (PVC) Pipe
PE Polyethylene (PE) Pipe with a Smooth Interior
CPE Corrugated Polyethylene (PE) Pipe with a Smooth Interior
PEPW Polyethylene (PE) Profile Wall Pipe

TABLE IIIIC: PLASTIC PIPE PERMITTED
FOR A GIVEN PIPE DIAMETER AND FILL HEIGHT OVER THE TOP OF THE PIPE
(Metric)

Nominal Diameter mm	Type 5 Fill Height: Greater Than 6 m, not exceeding 7.5 m				Type 6 Fill Height: Greater Than 7.5 m, not exceeding 9 m				Type 7 Fill Height: Greater Than 9 m, not exceeding 10.5 m	
	PVC	CPVC	PVCPW -794	PVCPW -304	PVC	CPVC	PVCPW -794	PVCPW -304	PVC	
250	X	*	NA	NA	X	*	NA	NA	X	
300	X	X	X	X	X	X	X	X	X	
375	X	X	X	X	X	NA	NA	NA	X	
450	X	X	X	X	X	NA	NA	NA	X	
525	X	X	X	X	X	NA	NA	NA	X	
600	X	X	X	X	X	NA	NA	NA	X	
750	X	NA	NA	NA	X	NA	NA	NA	X	
900	X	NA	NA	NA	X	NA	NA	NA	X	
1000	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1200	NA	NA	NA	NA	NA	NA	NA	NA	NA	

PVC Polyvinyl Chloride (PVC) Pipe

CPVC Corrugated Polyvinyl Chloride (PVC) Pipe With a Smooth Interior

PVCPW-794 Polyvinyl Chloride (PVC) Profile Wall Pipe-794

PVCPW-304 Polyvinyl Chloride (PVC) Profile Wall Pipe-304

X This material may be used for the given pipe diameter and fill height.

NA This material is Not Acceptable for the given pipe diameter and fill height.

* May be used if Bureau of Materials and Physical Research approves and with manufacturer's certification.

542.04 Method I Construction. Unless otherwise permitted in writing by the Engineer because of conditions encountered in construction, all pipe culverts, except entrance culverts, shall be constructed according to the following.

- (a) Removal and Replacement of Unstable or Unsuitable Material or Rock. Where unstable material such as soft or spongy soil, unsuitable material, or rock in either ledge or boulder formation is encountered at locations along the line of the pipe culvert and at the grade established for the culvert, the material or rock shall be removed and replaced before proceeding with the construction.

The unstable and unsuitable material shall be removed to a depth determined by the Engineer and for a width of one diameter (or equivalent diameter) of the pipe on each side of the pipe culvert, and replaced with aggregate. Rock shall be removed to an elevation 1 ft (300 mm) lower than the bottom of the pipe or to a depth equal to 1/2 in./ft (40 mm/m) of ultimate fill height over the top of the pipe culvert, whichever is the greater depth, and for a width as specified in (b) below, and replaced with aggregate. Replacement material shall be placed in 8 in. (200 mm) lifts, loose measurement, and compacted by mechanical means to the satisfaction of the Engineer.

- (b) Trenching. Pipe culverts shall be constructed in trenches free of water, excavated either in embankments or natural ground. Water shall be removed by use of a diversion channel or by other methods approved by the Engineer.

When all or a portion of a pipe will be in fill, the embankment, or a portion thereof, shall be constructed prior to excavating the trench. The embankment shall be constructed to a height which will provide approximately 1 ft (300 mm) of cover over the pipe, except that in no case shall the height of the embankment constructed result in a finished trench depth exceeding 5 ft (1.5 m). The width of the top of the embankment shall be a minimum of 13 ft (4 m) on each side of the pipe culvert, measured at right angles to its centerline, and the longitudinal slopes shall be 1:6 (V:H) or flatter. The embankment shall be constructed according to the requirements of Section 205, except the material shall be select material from excavation or borrow, meeting the approval of the Engineer.

Trenches shall be excavated to an elevation 4 in. (100 mm) below the bottom of the pipe and to the following widths.

Inside Diameter or Equivalent Diameter of Pipe	Required Trench Width On Each Side of the Pipe
24 in. (600 mm) and less	9 in. (225 mm)
Greater than 24 in. (600 mm) up to 48 in. (1.2 m)	12 in. (300 mm)
Greater than 48 in. (1.2 m)	18 in. (450 mm)

The faces of the excavated trench shall be vertical. If the width of the trench at the top exceeds the maximum horizontal dimension of the pipe by more than the above specified widths as a result of careless or faulty construction methods, that portion of the trench shall be corrected by backfilling in 8 in. (200 mm) lifts and again excavating the trench to the required width.

- (c) Preparation of Foundation. Well compacted aggregate, at least 4 in. (100 mm) in depth below the pipe culvert, shall be placed the entire width of the trench and for the length of the pipe culvert, except well compacted impervious material shall be used for the outer 3 ft (1 m) at each end of the pipe culvert. When the trench has been widened by the removal and replacement of unstable or unsuitable material, the foundation material shall be placed for a width not less than the above specified widths on each side of the pipe culvert. The aggregate and impervious material shall be compacted by mechanical means to the satisfaction of the Engineer.

When pipe having bells or hubs is used, cross trenches not more than 2 in. (50 mm) wider than the bell or hub shall be excavated to provide uniform bearing along the length of the pipe.

- (d) Laying Pipe. No pipe culvert shall be placed until the trench and the prepared foundation have been approved by the Engineer.

The pipe shall be laid so that the flow line of the finished culvert will be at the grade shown on the plans or established by the Engineer. Laying of pipes shall commence at the outlet end, with the spigot ends of the pipe pointing in the direction of the flow, and proceed toward the inlet end with pipes abutting.

The ends of the pipe shall be carefully cleaned before the pipes are placed and the pipes shall be placed to avoid unnecessary handling on the foundation. As each length of the pipe is laid, the ends of the pipe shall be protected to prevent the entrance of any material. The pipes shall be fitted and matched so that when laid in the work, they will form a culvert with a smooth, uniform invert.

All joints in concrete culverts shall be sealed with rubber gaskets, preformed flexible joint sealants, mastic joint sealer, or external sealing bands. When mastic joint sealer is used, the material shall completely fill the joint after the pipes have been brought together. After each joint is sealed, it shall be wiped clean on the inside. Each section of pipe shall be pushed or pulled to the section in place to ensure tight joints. Pipe having a diameter or equivalent diameter greater than 42 in. (1 m) shall be set or "brought home" with a winch, come-a-long, or other positive means.

Handling holes in concrete pipe shall be filled with a precast concrete plug and sealed with mastic or mortar; or filled with a polyethylene plug. The plug shall not project beyond the inside surface after installation.

When corrugated steel or aluminum alloy culvert pipe (including bituminous coated steel or aluminum and precoated steel) is used, the pipe shall be placed such that the longitudinal lap is placed at the sides and separate

sections of pipe shall be joined with a hugger-type band. When the pipes are fabricated with a smooth sleeve-type coupler, the gasket material shall be according to Article 1006.01.

PVC and PE pipes shall be joined according to the manufacturer's specifications.

- (e) Elongation. Circular corrugated steel or aluminum alloy culvert pipe (including bituminous coated steel or aluminum and precoated steel) that are specified as elongated in Table IB or IC shall be elongated vertically 5 percent \pm 0.75 percent out of a round before any fill is placed. The pipe, except for bituminous coated corrugated steel or aluminum culvert pipe, shall be elongated by one of the following methods.

- (1) Deformation during fabrication.
- (2) Elongation by the use of wires, rods, or straps during fabrication.
- (3) Elongation at the time of installation by the use of vertical struts, wedged or jacked inside the pipe in a manner approved by the Engineer.

Bituminous coated corrugated steel or aluminum culvert pipe shall be elongated by either method (1) or (2) prior to coating.

Pipe elongated by the manufacturer shall be marked to show the top. The pipe shall be stored, transported, and handled in such a manner so that at the time of installation the pipe shall have retained its elongation.

When the pipe is elongated by method (2) or (3), it shall be installed in a manner that will permit the gradual reduction of elongation as the fill over the pipe is placed. This reduction in elongation shall be as directed by the Engineer and may be accomplished by the use of softwood compression caps when struts or jacks are used, or by the use of turnbuckles or other devices when wires, rods, or straps are used.

After the fill has been placed and compacted, all struts, wires, rods, or straps shall be removed and any holes in the pipe resulting from their use shall be plugged in a manner satisfactory to the Engineer. Heavy asphaltic or tar material, or other material, or a device meeting the approval of the Engineer may be used to plug the holes.

No strutting or elongation will be permitted on corrugated steel or aluminum (including bituminous coated steel or aluminum and precoated steel) pipe arches.

- (f) Backfilling. As soon as the condition of the pipe culvert will permit, the entire width of the trench shall be backfilled with aggregate to a height of at least the center of the pipe. The aggregate shall be placed longitudinally along the pipe culvert, except at the outer 3 ft (1 m) at each end of the culvert which shall be backfilled with impervious material. The elevation of the backfill material on each side of the pipe shall be the same. The space

under the pipe shall be completely filled. The aggregate and impervious material shall be placed in lifts not exceeding 8 in. (200 mm) in depth, loose measurement, and compacted by mechanical means to the satisfaction of the Engineer.

When using flexible pipe, as listed in the first table of Article 542.03, the aggregate shall be continued to a height of at least 1 ft (300 mm) above the top of the pipe and compacted to a minimum of 95 percent of standard lab density by mechanical means.

The installed pipe and its embedment shall not be disturbed when using movable trench boxes and shields, sheet pile, or other trench protection.

The remainder of the trench shall be backfilled as follows.

- (1) Trench Backfill. For trenches made in the subgrade of the proposed improvement, and trenches where the inner edge of the trench is within 2 ft (600 mm) of the proposed edge of pavement, curb, gutter, curb and gutter, stabilized shoulder, or sidewalk, the remainder of the trench shall be backfilled with trench backfill material meeting the requirements of Section 208. The material shall be placed in lifts not exceeding 8 in. (200 mm) in depth, loose measurement, and compacted to a minimum of 85 percent of standard lab density by mechanical means.
- (2) Select Material. For all other trenches, the remainder of the trench shall be backfilled with select material. The select material shall be from excavation or borrow, free from large or frozen lumps, clods, or rock, meeting the approval of the Engineer. The material shall be placed in lifts not exceeding 8 in. (200 mm) in depth, loose measurement, and compacted to 95 percent of standard lab density by mechanical means.

Before compaction, each lift shall be wetted or dried to bring the moisture content within 80 to 110 percent of optimum as determined according to AASHTO T 99 (Method C).

The Contractor may, at no additional cost to the Department, backfill the remainder of the trench with aggregate in lieu of select material. The aggregate shall be placed in lifts not exceeding 8 in. (200 mm) in depth, loose measurement and compacted by mechanical means to the satisfaction of the Engineer.

The outer 3 ft (1 m) at each end of all trenches shall be backfilled with impervious material. The material shall be placed in lifts not exceeding 8 in. (200 mm) in depth, loose measurement and compacted to 95 percent of standard lab density by mechanical means.

In lieu of trench backfill or select material, the Contractor may, at no additional cost to the Department, backfill the entire trench, excepting the outer 3 ft (1 m), with controlled low-strength material according to Section 593.

All backfill material shall be placed in such a manner as not to damage the culvert. The filling of the trench shall be carried on simultaneously on both sides of the pipe.

When the trench has been widened for the removal and replacement of unstable or unsuitable material, the backfilling with aggregate and impervious material, will be required for a width of at least the specified widths on each side of the pipe. The remaining width of each lift may be backfilled with select material. Each 8 in. (200 mm) lift for the entire trench width shall be completed before beginning the placement of the next lift.

- (g) Embankment. When the top of the completed backfill is less than 1 ft (300 mm) above the top of the pipe, embankment shall be constructed to an elevation of 1 ft (300 mm) over the top of the pipe. The width and longitudinal slopes of the embankment shall be as specified in Article 542.04(b).

The embankment shall be constructed according to Section 205, except the material shall be select material, from excavation or borrow, meeting the approval of the Engineer. While constructing the embankment, no loads, other than the equipment permitted by the Engineer for the construction of the embankment, shall be introduced upon the pipe culvert and no heavy earth-moving equipment will be permitted within 4 ft (1.2 m) of either side of the pipe culvert.

- (h) Additional Embankment. After the trench has been backfilled and embankment constructed to an elevation of 1 ft (300 mm) over the top of the pipe culvert, additional embankment shall be constructed before the Contractor will be permitted to introduce any loads upon the pipe culvert. The required cover, including any embankment cover over the pipe and additional embankment, shall be sufficient for the maximum load, including the weight of equipment, which the Contractor proposes to operate or move across the pipe culvert. The total cover required for various loadings shall be as shown in Table IV, Wheel Loads and Total Cover.

Additional embankment shall be constructed according to Section 205. Its width on each side of the pipe culvert shall be 13 ft (4 m) and the longitudinal slopes shall not be steeper than 1:6 (V:H). The width of the additional embankment, measured along the pipe culvert, shall be the actual fill width indicated on the cross sections at the elevation required in the table below or sufficient to accommodate two-way traffic of the Contractor's grading operations and so no equipment is operated within 10 ft (3 m) of either shoulder line, whichever is the least.

Where the elevation of the additional embankment is above the elevation of the finished embankment, the Contractor shall remove it at the time of final grading operations.

Where the elevation of the finished embankment is higher than the additional embankment, the Contractor shall scarify the surface of the slopes and the top of the embankment.

Table IV: Wheel Loads and Total Cover											
Pipe Type	Nominal or Equivalent Diameter in.	Wheel Load in tons									Total Cover in feet
		1	5	10	15	20	25	30	35	40	
Type 1 & 4	8 to 108, incl.	1.0	2.0	3.0	4.0	5.0	5.5	6.5	7.5	8.5	10.5
Type 2 & 3	8 to 108, incl.	2.0	3.0	4.0	5.5	7.0	8.5	10.0	11.5	13.0	15.0
Type 5 & 6	8 to 72, incl.	1.0	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
	78 to 108, incl.	1.0	1.5	2.0	3.0	3.5	4.0	4.5	5.0	5.5	6.0
Type 7	8 to 72, incl.	1.0	1.5	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.5
	78 to 108, incl.	1.0	1.0	2.0	2.0	3.0	3.0	3.5	3.5	4.0	4.5

Table IV: Wheel Loads and Total Cover (Metric)												
		Wheel Load in kiloNewtons										
		9	44	89	133	178	223	267	311	356	400	445
Pipe Type	Nominal or Equivalent Diameter mm	Total Cover in meters										
Type 1 & 4	200 to 2700, incl.	0.3	0.6	0.9	1.2	1.5	1.7	2.0	2.3	2.6	2.9	3.2
Type 2 & 3	200 to 2700, incl.	0.6	0.9	1.2	1.7	2.1	2.6	3.0	3.5	4.0	4.3	4.6
Type 5 & 6	200 to 1800, incl.	0.3	0.6	0.8	0.9	1.1	1.2	1.4	1.5	1.5	1.7	1.8
	1950 to 2700, incl.	0.3	0.5	0.6	0.9	1.1	1.2	1.4	1.5	1.5	1.7	1.8
Type 7	200 to 1800, incl.	0.3	0.5	0.6	0.8	0.9	0.9	1.1	1.1	1.2	1.2	1.4
	1950 to 2700, incl.	0.3	0.3	0.6	0.6	0.9	0.9	1.1	1.1	1.2	1.2	1.4

- (i) Deflection Testing for Pipe Culverts. All PE and PVC pipe culverts shall be tested for deflection not less than 30 days after the pipe is installed and the backfill compacted. The testing shall be performed in the presence of the Engineer.

For PVC and PE pipe culverts with diameters 24 in. (600 mm) or smaller, a mandrel drag shall be used for deflection testing. For PVC and PE pipe culverts with diameters over 24 in. (600 mm), deflection measurements other than by a mandrel shall be used.

Where the mandrel is used, the mandrel shall be furnished by the Contractor and pulled by hand through the pipeline with a suitable rope or cable connected to each end. Winching or other means of forcing the deflection gauge through the pipeline will not be allowed.

The mandrel shall be of a shape similar to that of a true circle enabling the gauge to pass through a satisfactory pipeline with little or no resistance. The mandrel shall be of a design to prevent it from tipping from side to side and to prevent debris build-up from occurring between the channels of the adjacent fins or legs during operation. Each end of the core of the mandrel shall have fasteners to which the pulling cables can be attached. The mandrel shall have nine various sized fins or legs of appropriate dimension for various diameter of pipes. Each fin or leg shall have a permanent marking that states its designated pipe size and percent of deflection allowable.

The outside diameter of the mandrel shall be 95 percent of the base inside diameter, where the base inside diameter is:

- (1) For all PVC pipe and Profile Wall PE pipe: as defined using ASTM D 3034 methodology.
- (2) For all other PE pipe: the average inside diameter based on the minimum and maximum tolerances specified in the corresponding ASTM or AASHTO material specifications.

If the pipe is found to have a deflection greater than that specified, that pipe section shall be removed, replaced, and retested.

542.05 Method II Construction. Method II Construction may be used to construct pipe culverts, except entrance culverts, only when specified or when physical conditions are encountered in construction which make the use of Method I Construction impractical and written permission is obtained from the Engineer. In Method II Construction, all or a portion of a pipe culvert may be constructed in a trench excavated in the existing ground prior to placement of the required embankment.

The construction procedures for Method II Construction shall be the same as previously specified in Article 542.04 for Method I Construction, except as follows.

- (a) Trenching. Trenching shall be according to Article 542.04(b), except the trench depth shall be such that the bottom of the pipe is at least one-tenth of its diameter (or equivalent diameter) below the top of the trench. When the bottom of the pipe is less than the specified distance below the natural ground line, sufficient embankment shall be constructed to an elevation that will provide the required pipe embedment.
- (b) Backfill and/or Embankment. Backfill and/or embankment extending to an elevation of 1 ft (300 mm) over the top of the pipe shall be constructed according to Articles 542.04 (f) and 542.04(g), except that the material up to the elevation of the center of the pipe and extending to a width of at least 18 in. (450 mm) on each side of the pipe, exclusive of the outer 3 ft (1 m) at each end of the pipe, shall consist of aggregate. At the outer 3 ft (1 m) at each end of the culvert, impervious material shall be used.

542.06 Method III Construction. Entrance culverts shall be constructed according to the following.

- (a) Trenching. Normally, trenching other than that necessary to place the pipe culvert to a depth equal to one-tenth of its external diameter will not be required. Additional trenching may be necessary in some cases due to the location of a pipe culvert. The trenching shall be performed as specified for Method II, except as follows.

The trench shall be excavated only to the bottom of the pipe culvert and for a width sufficient to place the pipe. The bottom of the trench shall be shaped to approximately the size and shape of the pipe culvert.

- (b) Preparation of Foundation. After the trench has been excavated for the entire length of the pipe culvert and any necessary removal and replacement of unstable or unsuitable material or rock has been completed, the bottom of the trench shall be shaped to substantially fit the exterior of the pipe. If necessary, material meeting the approval of the Engineer shall be used to fill depressions. The material comprising the foundation shall then be compacted to the satisfaction of the Engineer.
- (c) Laying Pipe. The pipe shall be laid as specified in Article 542.04(d).
- (d) Backfill and/or Embankment. As soon as the condition of the pipe culvert will permit, the trench shall be backfilled and/or embankment constructed.

The material used shall be select material, meeting the approval of the Engineer, from excavation or borrow. The material shall be placed in lifts not exceeding 8 in. (200 mm), loose measurement, and compacted by mechanical means to the satisfaction of the Engineer. Special care shall be taken to completely fill the space under the pipe. The material shall be placed to an elevation 1 ft (300 mm) above the top of the pipe culvert or to the finished grade, whichever is the lesser height.

When embankment is being constructed, the material used for its construction shall be placed to a width, on each side of the pipe culvert, not less than one diameter of the pipe.

- (e) Deflection Testing. Deflection testing for entrance culverts may be required at the option of the Engineer. When required, it shall be according to Article 542.04(i).

542.07 End Treatment. When an end treatment is required, it will be shown on the plans. When a particular type of end treatment is specified, only that type shall be used.

When the pipe is at a 15 degree skew or less with the roadway, the diameter is 84 in. (2100 mm) or less, and an end treatment is required but the type of treatment is not specified on the plans, the Contractor shall have the option of using either a cast-in-place reinforced concrete end section or a prefabricated end section of precast reinforced concrete or metal. When a prefabricated end section is used, it shall be of the same material as the pipe culvert, except for polyethylene (PE) and polyvinylchloride (PVC) pipes which shall have metal end sections.

- (a) Cast-In-Place Reinforced Concrete End Section. Cast-in-place reinforced concrete end sections shall be constructed of Class SI concrete according to the requirements of Section 503 and the details shown on the plans.
- (b) Precast Reinforced Concrete Flared End Sections. Precast reinforced concrete flared end sections shall be constructed according to the details shown on the plans.

End blocks and grating for precast reinforced concrete flared end sections shall be according to the following.

- (1) End Blocks. End blocks shall be either precast or cast in place, and shall be in proper position and backfilled according to the applicable paragraphs of Article 502.10 prior to the installation of the precast reinforced concrete flared end sections.
- (2) Gratings. Gratings shall be fabricated and installed as shown on the plans.

Structural steel shapes and plates shall be according to the requirements of Article 1006.04. Galvanized steel pipe shall be according to the requirements of Article 1006.27(b). Bolts, nuts, and washers shall be according to the requirements of Article 1006.27(f).

Fabrication of the grating shall be completed and ready for assembly before galvanizing.

- (c) Metal End Sections. Metal end sections shall be fabricated of aluminum or steel, and all component parts shall be of the same material. When steel end sections are used, the base metal, rivets and spelter coating shall be according to AASHTO M 36 (M 36M). When aluminum end sections are used, the material shall be according to AASHTO M 196 (M 196M). Toe plates shall be furnished and the metal thickness shall be the same as that used in the end section.

Fabrication shall be according to the dimensions and details shown on the plans. All 3-piece bodies shall have 0.109 in. (2.77 mm) sides and 0.138 in. (3.51 mm) center panels. Width of center panels shall be greater than 20 percent of the pipe periphery. Multiple panel bodies shall have lap seams which shall be tightly jointed with 3/8 in. (M10) rivets or bolts.

- (d) Inlet Boxes, General. Inlet boxes shall be constructed as shown on the plans and shall be either cast-in-place or precast units.

When inlet boxes are cast-in-place, they shall be constructed of Class SI concrete according to the applicable requirements of Section 503.

When precast units are used, they shall be fabricated according to Article 1042.08. A 3 in. (75 mm) deep bedding of aggregate shall be provided under the full width and length of the unit.

For both cast-in-place and precast units, the lap length of reinforcement bars shall be 13 in. (325 mm) and exposed edges of concrete shall be beveled 3/4 in. (20 mm).

Excavation and backfill shall be performed according to the applicable portions of Section 502. All voids around the pipe entrance, both inside and out, shall be sealed with mortar.

- (1) Inlet Box, Standards 542501, 542506, 542511, 542516, 542521, 542536, and 542541. Galvanized steel pipe shall meet the requirements of ASTM A 53, Grade B, Schedule 40. Galvanized U-bolts, nuts, and washers shall meet the requirements of Article 1006.27(f). Steel plates shall meet the requirements of Article 1006.04, and shall be galvanized according to the requirements of AASHTO M 111 after fabrication.
- (2) Inlet Box, Standards 542526, 542531, and 542546. Grating and frames shall be steel or cast grating fabricated according to the details shown on the plans and shall be approved by the Engineer. Steel grating and frames shall be according to Article 1006.04 and shall be galvanized according to requirements of AASHTO M 111 after fabrication. Cast grating shall be according to Article 1006.15, Grade 60-40-18, or to Article 1006.14. Cast frames shall be according to Article 1006.14. Cast grating and frames shall not be galvanized.

Either steel frames and grating or cast frames and grating may be used at the Contractor's option, but steel frames with cast grating or cast frames with steel grating will not be permitted.

Pressure lock type steel grating and riveted steel grating with reticulate bars will be accepted for galvanizing according to the requirements of AASHTO M 111.

Steel grating shall seat firmly in the frame but shall not be secured to the frame. The grating shall be cut in such manner that all riveted or welded connections are left intact. The edges of the main bearing bars

shall be laterally supported by transverse bars. Grating shall be approved by the Engineer. All welding shall be done according to the applicable requirements of Section 505, and shall be done before galvanizing.

- a. Standards 542526 and 542531. The steel grating shall have the main bearing bars running perpendicular to the centerline of the inlet box. The main bearing bars shall have a minimum section modulus of 3.29 cu in./ft (176,900 cu mm/m) width of grating. The cross sectional shape shall be rectangular or a modified "I" but shall not have any flanges which would retain trash. The length and width of the grating shall be such as to leave no more than 5/8 in. (16 mm) clearance on either side when placed in the frame.
- b. Standard 542546. The steel grating shall have the main bearing bars running parallel to the centerline of the median. The main bearing bars shall be as specified or shall be 3 1/2 in. (89 mm) in depth and have a minimum section modulus of 3.78 cu in./ft (203,200 cu mm/m) width of grating with a maximum spacing of 2 in. (50 mm) center-to-center.

542.08 Pipe Elbows, Tees, and Collars. Pipe elbows and tees shall be installed at the locations shown on the plans. The degree of elbow and the pipe size required for elbows and tees will be detailed on the plans and shall be verified in the field.

Elbows, tees, and collars shall be of the same material as the pipe culvert.

- (a) Reinforced Concrete. Reinforced concrete elbows and tees shall be fabricated according Article 1042.06.

Reinforced concrete collars shall be constructed according to Section 503 and as detailed on the plans.

- (b) Metal. The bonding or connecting device for the elbows, tees, and/or collars will be approved by the Engineer prior to use.

542.09 Pipe Culverts (Temporary). Pipe culverts used as drainage structures for proposed temporary connections and detour roads shall be designated Pipe Culverts (Temporary) and shall be furnished, installed, maintained, and removed as specified, except that the material for the pipe culvert need not be new material.

Used pipe with a thickness equal to or greater than that required in Table IB or IC of Article 542.03 may be used provided it meets the approval of the Engineer. The Engineer will visually inspect the pipe for acceptance. Small dents or inadequate galvanizing on the pipe will not be cause for rejection.

After the temporary connection or detour road has been removed, the pipe culvert shall become the property of the Contractor.

542.10 Method of Measurement. Pipe culverts will be measured for payment in place in feet (meters), except the length measured will not exceed the length

shown on the plans or authorized in writing by the Engineer. When elbows or tees are included in pipe culverts, the measured length of the culvert shall exclude the length of the elbow or tee section.

Excavation in rock will be measured for payment according to Article 502.12.

Trench backfill will be measured for payment according to Article 208.03.

Embankment will be measured for payment according to Article 202.07 and/or Article 204.07.

Additional embankment and its subsequent removal will not be measured for payment.

542.11 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for PIPE CULVERTS, or PIPE CULVERTS (TEMPORARY), of the class and type specified; or PIPE CULVERTS, SPECIAL, of the diameters or equivalent round size specified, and of the particular kind of material when specified.

The removal of unstable or unsuitable material, or rock below plan bedding grade, and the replacement with the specified material, including additional excavation required to widen the trench will be paid for according to Article 109.04 unless the contract contains unit prices for the work included.

Excavation in rock will be paid for according to Article 502.13.

Embankment will be paid for according to Article 202.08 and/or Article 204.08.

Trench backfill will be paid for according to Article 208.04

When the Contractor has the option of using either cast-in-place reinforced concrete end sections or prefabricated end sections as specified in Article 542.07, the work will be paid for at the contract unit price per each for END SECTIONS, for the size of pipe specified.

When specified on the plans, precast reinforced concrete flared end sections will be paid for at the contract unit price per each for PRECAST REINFORCED CONCRETE FLARED END SECTIONS, of the diameter or equivalent round size specified.

When specified on the plans, steel end sections and aluminum end sections will be paid for at the contract unit price per each for STEEL END SECTIONS and ALUMINUM END SECTIONS, respectively, of the diameter or equivalent round size specified.

End sections for polyvinylchloride (PVC) and polyethylene (PE) culvert pipes will be paid for at the contract unit price per each for METAL END SECTIONS, of the diameter specified.

When cast-in-place reinforced concrete end sections are specified on the plans, the work will be paid for at the contract unit price per each for CAST-IN-PLACE REINFORCED CONCRETE END SECTIONS, of the diameter specified.

When cast-in-place concrete collars are specified on the plans, the concrete will be paid for at the contract unit price per cubic yard (cubic meter) for CONCRETE COLLAR. Reinforcement will be paid for according to Section 508. Expansion bolts, when required, will be paid for according to Section 540.

When specified on the plans, elbows and tees for polyethylene or metal pipe will be paid for at the contract unit price per each of PIPE ELBOW and PIPE TEE, of the diameter specified.

Grating for precast reinforced concrete flared end sections will be paid for at the contract unit price per each for GRATING FOR CONCRETE FLARED END SECTION, of the size specified.

Inlet boxes for median slopes and for side slopes will be paid for at the contract unit price per each for INLET BOX, STANDARD 542501; INLET BOX, STANDARD 542521; INLET BOX, STANDARD 542511; INLET BOX, STANDARD 542506; INLET BOX, STANDARD 542536; INLET BOX, STANDARD 542516; and INLET BOX, STANDARD 542541.

Inlet boxes for median ditch checks will be paid for at the contract unit price per each for INLET BOX, STANDARD 542526 or INLET BOX, STANDARD 542531.

Inlet boxes to be placed flush in medians will be paid for at the contract unit price per each for FLUSH INLET BOX FOR MEDIAN, STANDARD 542546.

Reinforced concrete pipe elbows will be paid for at the contract unit price per each for REINFORCED CONCRETE PIPE ELBOW, of the diameter specified.

Reinforced concrete pipe tees will be paid for at the contract unit price per each for REINFORCED CONCRETE PIPE TEE, of the pipe diameter and riser diameter specified.

SECTION 543. INSERTION LINING OF PIPE CULVERTS

543.01 Description. This work shall consist of insertion lining of existing pipe culverts and the grouting of the annular space between the existing culvert and the liner pipe.

543.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Polyethylene (PE) Pipe with a Smooth Interior (Note 1)	1040.04
(b) Polyethylene (PE) Profile Wall Pipe (Note 1)	1040.04
(c) Reinforced Plastic Mortar (RPM) Pipe (Note 1)	1040.05
(d) Nonshrink Grout.....	1024.02
(e) Corrugated PVC with a Smooth Interior (Note 1)	1040.03
(f) Grout Mixture (Note 2)	1024.01
(g) Grout Stop Mixture	1024.01

Note 1. Insertion linings are specified to minimum allowable inside diameters. Any of the listed pipe materials are permitted if the inside diameter requirement is met.

Note 2. The grout mixture shall be 6.50 hundredweight/cu yd (385 kg/cu m) of portland cement plus fine aggregate and water. Fly ash may replace a maximum of 5.25 hundredweight/cu yd (310 kg/cu m) of the portland cement. The water/cement ratio, according to Article 1020.06, shall not exceed 0.60. An air-entraining admixture shall be used to produce an air content, according to Article 1020.08, of not less than 6.0 percent nor more than 9.0 percent of the volume of the grout. The Contractor shall have the option to use a water-reducing or high range water-reducing admixture.

Nominal Size (in.)	PE-F714		RPM-D3262		Profile Wall-F894		PVC-F949	
	I.D. (in.)	O.D. (in.)	I.D. (in.)	O.D. (in.)	I.D. (in.)	O.D. (in.)	I.D. (in.)	O.D. (in.)
10					10.00	11.20	9.8	10.8
12	11.92	12.75			12.00	13.47	11.7	12.8
13	12.50	13.38						
14	13.09	14.00						
15					15.00	16.85	14.3	15.7
16	14.96	16.00						
18	16.80	18.00	18.0	19.5	18.00	20.24	17.6	19.2
20	18.67	20.00	20.0	21.6				
21					21.00	23.65	20.1	22.6
22	20.54	22.00						
24	22.40	24.00	24.0	25.8	24.00	27.06	23.5	25.6
27					27.00	30.43	26.4	28.9
28	26.14	28.00						
30			30.0	32.0	30.00	33.82	29.5	32.1
32	29.50	31.59						
36	33.61	36.00	36.0	38.3	36.00	40.65	35.5	38.7
40	36.85	39.47			40.00	45.20		

Nominal Size (in.)	PE-F714		RPM-D3262		Profile Wall-F894		PVC-F949	
	I.D. (in.)	O.D. (in.)	I.D. (in.)	O.D. (in.)	I.D. (in.)	O.D. (in.)	I.D. (in.)	O.D. (in.)
42	39.21	42.00	42.0	44.5	42.00	47.47		
48	44.24	47.38	48.0	50.8	48.00	53.76		
54			54.0	57.1	54.00	60.48		
55	51.63	55.30						
60			60.0	62.9	60.00	67.20		
63	59.02	63.21						
66			66.0	69.2	66.00	73.92		
72			72.0	75.4	72.00	80.64		
78			78.0	81.6	78.00	87.36		
84			84.0	88.0	84.00	94.08		
90			90.0	94.3	90.00	100.80		
96			96.0	100.6	96.00	107.52		

Nominal Size (mm)	PE-F-714		RPM-D3262		ProfileWall-F894		PVC-F949	
	I.D. (mm)	O.D. (mm)	I.D. (mm)	O.D. (mm)	I.D. (mm)	O.D. (mm)	I.D. (mm)	O.D. (mm)
250					250.0	284.5	250.1	273.9
300	302.8	323.9			300.0	342.1	297.6	325.0
325	317.5	339.9						
350	332.5	355.6						
375					375.0	428.0	364.2	397.7
400	380.0	406.4						
450	426.7	457.2	457.2	495.3	450.0	514.1	445.8	486.5
500	474.2	508.0	508.0	548.6				
525					525.0	600.7	525.9	573.7
550	521.7	558.8						
600	569.0	609.6	609.6	655.3	600.0	687.3	596.1	649.7
675					675.0	772.9	671.6	733.0
700	664.0	711.2						
750			762.0	812.8	750.0	859.0	748.5	816.6
800	749.3	802.4						
900	853.7	914.4	914.4	922.8	900.0	1032.5	901.1	984.0
1000	936.0	1002.5			1000.0	1148.1		
1050	995.9	1066.8	1066.8	1130.3	1050.0	1205.7		
1200	1123.7	1203.5	1219.2	1290.3	1219.2	1365.5		
1350			1371.6	1450.3	1371.6	1536.2		
1375	1311.4	1404.6						
1500			1524.0	1597.7	1524.0	1706.9		
1600	1499.1	1605.5						
1650			1676.4	1757.7	1676.4	1877.6		
1800			1828.8	1915.2	1828.8	2048.2		
1950			1981.2	2072.6	1981.2	2218.9		
2100			2133.6	2235.2	2133.6	2389.6		
2250			2286.0	2395.2	2286.0	2560.3		
2400			2438.4	2555.2	2438.4	2731.0		

CONSTRUCTION REQUIREMENTS

543.03 General. Prior to installing the insertion lining, the existing culvert shall be completely cleaned.

PE pipe with a smooth interior shall be joined into a continuous length by the butt fusion method according to ASTM D 2657 or by an approved screw-on or push-on joint. PE profile wall pipe shall be joined by heat fusion, extrusion, welding, screw-on, or other approved connections. RPM pipe or corrugated PVC with a smooth interior pipe shall be joined according to the manufacturer's recommendations using joint lubricant. The joining may be accomplished in a jacking pit or other convenient location where the assembled liner can be brought into alignment with the existing culvert bore without damage. The Engineer will approve each joint before each section of liner pipe is inserted.

The insertion may be made by pushing or pulling the assembled liner pipe from either end of the culvert. The Engineer may require the liner to have a temporary nose cone or plug to guide the liner pipe past minor obstructions. The insertion operation shall not cause joints to separate nor damage the liner pipe.

After the liner has been completely inserted and has been inspected in place by the Engineer, it shall be cut off flush with the ends of the existing culvert or as otherwise directed by the Engineer. Liner pipe shall be allowed to cool to the temperature of the existing culvert before it is cut off. The entire length of the annular space between the existing culvert and the liner pipe shall be filled with a grout mixture.

Prior to filling the annular space, the upstream and downstream ends of the annular space shall have a grout stop mixture. The grout stop mixture shall be one part cement and two parts sand mixed with water. The grout stop shall be no closer than 6 in. (150 mm) from the end. Holes shall be required at the grout stop to allow air to escape when pumping grout and to allow verification that the annular space has been filled with grout.

When the grout is pumped into the annular space, the Contractor shall prevent the floating of the liner pipe. This shall be accomplished by any of the following methods.

- (a) Intermittent Pumping Method. Small amounts of grout shall be pumped into the annular space and allowed to harden. This shall continue until the bond between the liner pipe and grout is sufficient to resist floating. The remainder of the annular space shall then be filled.
- (b) Bracing Method. Braces shall be installed in the annular space to prevent floating of the liner pipe. Only braces which do not damage the liner pipe shall be used.
- (c) Water Fill Method. The liner pipe shall be temporarily filled with water before filling the annular space with grout.

The pumping operation shall effectively fill the annular space along the entire length, but shall be performed in a manner that does not distort the liner pipe. The

pressure developed in the annular space shall not exceed the liner pipe manufacturer's recommended value.

Upon completion of the pumping operation, the remaining 6 in. (150 mm) at the upstream and downstream ends shall be filled with a nonshrink grout. Only enough water to make a stiff but workable nonshrink grout shall be used.

543.04 Method of Measurement. This work will be measured for payment in place in feet (meters).

Excavation in rock will be measured for payment according to Article 502.12.

543.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for INSERTION CULVERT LINER of the inside diameter specified.

Excavation in rock will be paid for according to Article 502.13.

SEWERS

SECTION 550. STORM SEWERS

550.01 Description. This work shall consist of constructing storm sewers.

550.02 Materials. Materials shall be according to the following.

Item	Article Section
(a) Clay Sewer Pipe	1040.02
(b) Extra Strength Clay Pipe	1040.02
(c) Concrete Sewer, Storm Drain, and Culvert Pipe	1042
(d) Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe	1042
(e) Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe (Note 1)	1042
(f) Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe (Note 1)	1042
(g) Polyvinyl Chloride (PVC) Pipe	1040.03
(h) Corrugated Polyvinyl Chloride (PVC) Pipe with a Smooth Interior	1040.03
(i) Polyvinyl Chloride (PVC) Profile Wall Pipe-794	1040.03
(j) Rubber Gaskets and Preformed Flexible Joint Sealants for Concrete Pipe	1056
(k) Mastic Joint Sealer for Pipe	1055
(l) External Sealing Band	1057
(m) Fine Aggregate (Note 2)	1003.04
(n) Coarse Aggregate (Note 3)	1004.05
(o) Reinforcement Bars and Welded Wire Fabric	1006.10
(p) Handling Hole Plugs	1042.16
(q) Polyvinyl Chloride (PVC) Profile Wall Pipe-304	1040.03
(r) Polyethylene (PE) Pipe with a Smooth Interior	1040.04
(s) Corrugated Polyethylene (PE) Pipe with a Smooth Interior	1040.04
(t) Polyethylene (PE) Profile Wall Pipe	1040.04

Note 1. The class of elliptical and arch pipe used for various storm sewer sizes and heights of fill shall conform to the requirements for circular pipe.

Note 2. The fine aggregate shall be moist.

Note 3. The coarse aggregate shall be wet.

550.03 Kinds of Material Permitted. When a Class of storm sewer is specified, the material shall be selected from the following table. When a particular material is specified, no other kind of material will be permitted.

Class	Materials
A	Rigid Pipes: Clay Sewer Pipe Extra Strength Clay Pipe Concrete Sewer, Storm Drain, and Culvert Pipe Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe
B	Rigid Pipes: Clay Sewer Pipe Extra Strength Clay Pipe Concrete Sewer, Storm Drain, and Culvert Pipe Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe Flexible Pipes: Polyvinyl Chloride (PVC) Pipe Corrugated Polyvinyl Chloride (PVC) Pipe with a Smooth Interior Polyvinyl Chloride (PVC) Profile Wall Pipe-794 Polyvinyl Chloride (PVC) Profile Wall Pipe-304 Polyethylene (PE) Pipe with a Smooth Interior Corrugated Polyethylene (PE) Pipe with a Smooth Interior Polyethylene (PE) Profile Wall Pipe

When a storm sewer diameter is specified, only a circular pipe will be permitted. When a round size equivalent is specified, only a reinforced concrete arch pipe or reinforced concrete elliptical pipe will be permitted.

When metric sizes are specified on the plans, the next larger available manufactured English pipe may be substituted at no additional cost to the Department.

The Contractor may, at no additional cost to the Department, substitute a stronger pipe of the same kind of material specified.

The kind of material and thickness or thickness class required for the various types of storm sewers shall be according to the following tables.

STORM SEWERS KIND OF MATERIAL PERMITTED AND STRENGTH REQUIRED FOR A GIVEN PIPE DIAMETER AND FILL HEIGHT OVER THE TOP OF THE PIPE																					
Norm. Dia. in.	Type 1 Fill Height: 3' and less with 1' minimum cover										Type 2 Fill Height: Greater than 3', not exceeding 10'										
	RCCP Class	CSP Class	ESCP	PVC	CPVC	PVCPW -794	PVCPW -304	PE	CPE	PEPW	RCCP Class	CSP Class	ESCP	PVC	CPVC	PVCPW -794	PVCPW -304	PE	CPE	PEPW	
10	NA	3	X	X	NA	NA	NA	X	NA	NA	NA	1	*X	X	**	NA	NA	X	NA	NA	
12	IV	NA	NA	X	X	X	X	X	X	X	III	1	*X	X	X	X	X	X	X	NA	
15	IV	NA	NA	X	X	X	X	X	X	X	III	2	X	X	X	X	X	X	X	NA	
18	IV	NA	NA	X	X	X	X	X	X	X	III	2	X	X	X	X	X	X	X	X	
21	IV	NA	NA	X	X	X	X	NA	NA	X	III	2	X	X	X	X	X	NA	NA	X	
24	IV	NA	NA	X	X	X	X	X	X	X	III	2	X	X	X	X	X	X	X	X	
27	IV	NA	NA	X	X	X	X	X	X	X	III	NA	X	X	X	X	X	X	X	X	
30	III	NA	X	X	X	X	X	X	X	X	III	NA	X	X	X	X	X	X	X	X	
33	III	NA	X	X	NA	X	X	X	X	X	III	NA	X	X	NA	X	X	X	X	X	
36	III	NA	X	X	X	X	X	X	X	X	III	NA	X	X	X	X	X	X	X	X	
42	II	NA	NA	NA	NA	X	X	X	X	X	III	NA	NA	NA	NA	NA	X	X	X	X	
48	II	NA	NA	NA	NA	X	X	X	X	X	III	NA	NA	NA	NA	NA	X	X	X	X	
54	II	NA	NA	NA	NA	NA	NA	NA	NA	NA	III	NA	NA	NA	NA	NA	NA	NA	NA	NA	
60	I	NA	NA	NA	NA	NA	NA	NA	NA	NA	II	NA	NA	NA	NA	NA	NA	NA	NA	NA	
66	I	NA	NA	NA	NA	NA	NA	NA	NA	NA	II	NA	NA	NA	NA	NA	NA	NA	NA	NA	
72	I	NA	NA	NA	NA	NA	NA	NA	NA	NA	II	NA	NA	NA	NA	NA	NA	NA	NA	NA	
78	I	NA	NA	NA	NA	NA	NA	NA	NA	NA	II	NA	NA	NA	NA	NA	NA	NA	NA	NA	
84	I	NA	NA	NA	NA	NA	NA	NA	NA	NA	II	NA	NA	NA	NA	NA	NA	NA	NA	NA	
90	I	NA	NA	NA	NA	NA	NA	NA	NA	NA	II	NA	NA	NA	NA	NA	NA	NA	NA	NA	
96	I	NA	NA	NA	NA	NA	NA	NA	NA	NA	II	NA	NA	NA	NA	NA	NA	NA	NA	NA	
102	I	NA	NA	NA	NA	NA	NA	NA	NA	NA	II	NA	NA	NA	NA	NA	NA	NA	NA	NA	
108	I	NA	NA	NA	NA	NA	NA	NA	NA	NA	II	NA	NA	NA	NA	NA	NA	NA	NA	NA	
RCCP	Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe										ESCP										Extra Strength Clay Pipe
CSP	Concrete Sewer, Storm Drain, and Culvert Pipe										PVC										Polyvinyl Chloride (PVC) Pipe
CPVC	Corrugated Polyvinyl Chloride (PVC) Pipe with a Smooth Interior										PE										Polyethylene (PE) Pipe with a Smooth Interior
PVCPW-794	Polyvinyl Chloride (PVC) Profile Wall Pipe-794										CPE										Corrugated Polyethylene (PE) Pipe with a Smooth Interior
PVCPW-304	Polyvinyl Chloride (PVC) Profile Wall Pipe-304										PEPW										Polyethylene (PE) Profile Wall Pipe
X	This material may be used for the given pipe diameter and fill height.																				
NA	This material is Not Acceptable for the given pipe diameter and fill height.																				
*	May also use standard strength Clay Sewer Pipe																				
**	May be used if Bureau of Materials and Physical Research approves and with manufacturer's certification.																				

STORM SEWERS (metric)																				
KIND OF MATERIAL PERMITTED AND STRENGTH REQUIRED FOR A GIVEN PIPE DIAMETER AND FILL HEIGHT OVER THE TOP OF THE PIPE																				
Nom. Dia.	Type 1										Type 2									
	Fill Height: 1 m and less with 0.3 m minimum cover										Fill Height: Greater than 1 m, not exceeding 3 m									
mm	RCCP Class	CSP Class	ESCP	PVC	CPVC	PVCPW -794	PVCPW -304	PE	CPE	PEPW	RCCP Class	CSP Class	ESCP	PVC	CPVC	PVCPW -794	PVCPW -304	PE	CPE	PEPW
250	NA	3	X	X	NA	NA	NA	X	NA	NA	NA	1	*X	X	**	NA	NA	X	NA	NA
300	IV	NA	NA	X	X	X	X	X	X	NA	III	1	*X	X	X	X	X	X	X	NA
375	IV	NA	NA	X	X	X	X	X	X	NA	III	2	X	X	X	X	X	X	X	NA
450	IV	NA	NA	X	X	X	X	X	X	NA	III	2	X	X	X	X	X	NA	NA	X
525	IV	NA	NA	X	X	X	X	X	NA	NA	III	2	X	X	X	X	X	X	NA	X
600	IV	NA	NA	X	X	X	X	X	X	X	III	2	X	X	X	X	X	X	X	X
675	IV	NA	NA	X	X	X	X	X	X	X	III	NA	X	X	X	X	X	X	X	X
750	III	NA	X	X	X	X	X	X	X	X	III	NA	X	X	X	X	X	X	X	X
825	III	NA	X	X	NA	X	X	X	X	X	III	NA	X	NA	NA	X	X	X	X	X
900	III	NA	X	X	X	X	X	X	X	X	III	NA	X	X	X	X	X	X	X	X
1050	II	NA	NA	NA	NA	X	X	X	X	X	III	NA	NA	NA	NA	NA	X	X	X	X
1200	II	NA	NA	NA	NA	X	X	X	X	X	III	NA	NA	NA	NA	X	X	X	X	X
1350	II	NA	NA	NA	NA	NA	NA	NA	NA	NA	III	NA	NA	NA	NA	NA	NA	NA	NA	NA
1500	I	NA	NA	NA	NA	NA	NA	NA	NA	NA	II	NA	NA	NA	NA	NA	NA	NA	NA	NA
1650	I	NA	NA	NA	NA	NA	NA	NA	NA	NA	II	NA	NA	NA	NA	NA	NA	NA	NA	NA
1800	I	NA	NA	NA	NA	NA	NA	NA	NA	NA	II	NA	NA	NA	NA	NA	NA	NA	NA	NA
1950	I	NA	NA	NA	NA	NA	NA	NA	NA	NA	II	NA	NA	NA	NA	NA	NA	NA	NA	NA
2100	I	NA	NA	NA	NA	NA	NA	NA	NA	NA	II	NA	NA	NA	NA	NA	NA	NA	NA	NA
2250	I	NA	NA	NA	NA	NA	NA	NA	NA	NA	II	NA	NA	NA	NA	NA	NA	NA	NA	NA
2400	I	NA	NA	NA	NA	NA	NA	NA	NA	NA	II	NA	NA	NA	NA	NA	NA	NA	NA	NA
2550	I	NA	NA	NA	NA	NA	NA	NA	NA	NA	II	NA	NA	NA	NA	NA	NA	NA	NA	NA
2700	I	NA	NA	NA	NA	NA	NA	NA	NA	NA	II	NA	NA	NA	NA	NA	NA	NA	NA	NA

RCCP	Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe	ESCP	Extra Strength Clay Pipe
CSP	Concrete Sewer, Storm Drain, and Culvert Pipe	PVC	Polyvinyl Chloride (PVC) Pipe
CPVC	Corrugated Polyvinyl Chloride (PVC) Pipe with a Smooth Interior	PE	Polyethylene (PE) Pipe with a Smooth Interior
PVCPW-794	Polyvinyl Chloride (PVC) Profile Wall Pipe-794	CPE	Corrugated Polyethylene (PE) Pipe with a Smooth Interior
PVCPW-304	Polyvinyl Chloride (PVC) Profile Wall Pipe-304	PEPW	Polyethylene (PE) Profile Wall Pipe
X	This material may be used for the given pipe diameter and fill height.		
NA	This material is Not Acceptable for the given pipe diameter and fill height.		
*	May also use standard strength Clay Sewer Pipe		
**	May be used if Bureau of Materials and Physical Research approves and with manufacturer's certification.		

STORM SEWERS KIND OF MATERIAL PERMITTED AND STRENGTH REQUIRED FOR A GIVEN PIPE DIAMETER AND FILL HEIGHT OVER THE TOP OF THE PIPE											
Nom. Dia. in.	Type 3 Fill Height: Greater than 10', not exceeding 15'						Type 4 Fill Height: Greater than 15', not exceeding 20'				
	RCCP Class	CSP Class	ESCP	PVC	CPVC	PVC/PW/PVCPW -794 -304	PEPWRCCP Class	PVC	CPVC	PVC/PW/PVCPW -794 -304	PVC/PW
10	NA	3	X	X	**	NA	NA	X	**	NA	NA
12	IV	NA	X	X	X	X	NA	X	X	X	X
15	IV	NA	X	X	X	X	NA	X	X	X	X
18	IV	NA	NA	X	X	X	X	X	X	X	X
21	IV	NA	NA	X	X	NA	X	X	X	X	X
24	IV	NA	NA	X	X	X	V	X	X	X	X
27	IV	NA	NA	X	X	X	V	X	X	X	X
30	IV	NA	NA	X	X	X	V	X	X	X	X
33	IV	NA	NA	X	NA	X	IV	X	NA	X	X
36	IV	NA	NA	X	NA	X	IV	X	NA	X	X
42	IV	NA	NA	NA	NA	X	IV	X	NA	X	X
48	IV	NA	NA	NA	NA	X	IV	X	NA	X	X
54	IV	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA
60	IV	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA
66	III	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA
72	III	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA
78	III	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA
84	III	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA
90	III	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA
96	III	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA
102	III	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA
108	III	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA

RCCP Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
 CSP Concrete Sewer, Storm Drain, and Culvert Pipe
 CPVC Corrugated Polyvinyl Chloride (PVC) Pipe with a Smooth Interior
 PVC/PW-794 Polyvinyl Chloride (PVC) Profile Wall Pipe-794
 PVC/PW-304 Polyvinyl Chloride (PVC) Profile Wall Pipe-304
 X This material is Not Acceptable for the given pipe diameter and fill height.
 NA This material is Not Acceptable for the given pipe diameter and fill height.
 ** May be used if Bureau of Materials and Physical Research approves and with manufacturer's certification.

STORM SEWERS (metric)																
KIND OF MATERIAL PERMITTED AND STRENGTH REQUIRED FOR A GIVEN PIPE DIAMETER AND FILL HEIGHT OVER THE TOP OF THE PIPE																
Nom. Dia.	Type 3										Type 4					
	Fill Height: Greater than 3 m, not exceeding 4.5 m										Fill Height: Greater than 4.5 m, not exceeding 6 m					
mm	RCCP Class	CSP Class	ESCP	PVC	CPVC	PVC	PCWPW -794	PVC	PEPW	RCCP Class	PVC	CPVC	PVC	PCWPW -794	PVC	PCWPW -304
250	NA	3	X	X	X	NA	NA	X	NA	NA	X	**	NA	NA	NA	NA
300	IV	NA	X	X	X	X	X	X	NA	V	X	X	X	X	X	X
375	IV	NA	NA	NA	X	X	X	X	NA	V	X	X	X	X	X	X
450	IV	NA	NA	NA	X	X	X	X	X	V	X	X	X	X	X	X
525	IV	NA	NA	NA	X	X	X	X	NA	V	X	X	X	X	X	X
600	IV	NA	NA	NA	X	X	X	X	X	V	X	X	X	X	X	X
675	IV	NA	NA	NA	X	X	X	X	X	V	X	X	X	X	X	X
750	IV	NA	NA	NA	X	X	X	X	X	V	X	X	X	X	X	X
825	IV	NA	NA	NA	X	NA	X	X	X	V	X	NA	NA	X	X	X
900	IV	NA	NA	NA	X	X	X	X	X	IV	X	X	X	X	X	X
1050	IV	NA	NA	NA	NA	X	X	X	X	IV	NA	NA	NA	X	X	X
1200	IV	NA	NA	NA	NA	X	X	X	X	IV	NA	NA	NA	X	X	X
1350	IV	NA	NA	NA	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA	NA	NA
1500	IV	NA	NA	NA	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA	NA	NA
1650	III	NA	NA	NA	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA	NA	NA
1800	III	NA	NA	NA	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA	NA	NA
1950	III	NA	NA	NA	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA	NA	NA
2100	III	NA	NA	NA	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA	NA	NA
2250	III	NA	NA	NA	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA	NA	NA
2400	III	NA	NA	NA	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA	NA	NA
2550	III	NA	NA	NA	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA	NA	NA
2700	III	NA	NA	NA	NA	NA	NA	NA	NA	IV	NA	NA	NA	NA	NA	NA
RCCP	Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe															
CSP	Concrete Sewer, Storm Drain, and Culvert Pipe															
PVC	Corrugated Polyvinyl Chloride (PVC) Pipe with a Smooth Interior															
PVC	Polyvinyl Chloride (PVC) Profile Wall Pipe-794															
PVC	Polyvinyl Chloride (PVC) Profile Wall Pipe-304															
X	This material may be used for the given pipe diameter and fill height.															
NA	This material is Not Acceptable for the given pipe diameter and fill height.															
**	May be used if Bureau of Materials and Physical Research approves and with manufacturer's certification.															

STORM SEWERS KIND OF MATERIAL PERMITTED AND STRENGTH REQUIRED FOR A GIVEN PIPE DIAMETER AND FILL HEIGHT OVER THE TOP OF THE PIPE												
Nom. Dia. in.	Type 5 Fill Height: Greater than 20', not exceeding 25'				Type 6 Fill Height: Greater than 25', not exceeding 30'				Type 7 Fill Height: Greater than 30', not exceeding 35'			
	RCCP Class	PVC	CPVC	PVC/PW -794	PVC/PW -304	RCCP Class	PVC	CPVC	PVC/PW -794	PVC/PW -304	RCCP Class	PVC
10	NA	X	**	NA	NA	NA	X	**	NA	NA	NA	X
12	V-3160D	X	X	X	X	V-3790D	X	X	X	X	V-4000D	X
15	V-3080D	X	X	X	X	V-3390D	X	NA	NA	NA	V-3575D	X
18	V	X	X	X	X	V-3115D	X	NA	NA	NA	V-3300D	X
21	V	X	X	X	X	V	X	NA	NA	NA	V-3110D	X
24	V	X	X	X	X	V	X	NA	NA	NA	V	X
27	V	X	NA	NA	NA	V	X	NA	NA	NA	V	X
30	V	X	NA	NA	NA	V	X	NA	NA	NA	V	X
33	V	X	NA	NA	NA	V	X	NA	NA	NA	V	X
36	V	X	NA	NA	NA	V	X	NA	NA	NA	V	X
42	V	NA	NA	NA	NA	V	NA	NA	NA	NA	V	NA
48	V	NA	NA	NA	NA	V	NA	NA	NA	NA	V	NA
54	V	NA	NA	NA	NA	V	NA	NA	NA	NA	V	NA
60	V	NA	NA	NA	NA	V	NA	NA	NA	NA	V	NA
66	IV	NA	NA	NA	NA	V	NA	NA	NA	NA	V	NA
72	IV	NA	NA	NA	NA	V	NA	NA	NA	NA	V	NA
78	IV	NA	NA	NA	NA	V	NA	NA	NA	NA	V	NA
84	IV	NA	NA	NA	NA	V	NA	NA	NA	NA	V	NA
90	IV	NA	NA	NA	NA	V	NA	NA	NA	NA	V	NA
96	IV	NA	NA	NA	NA	V	NA	NA	NA	NA	V	NA
102	IV	NA	NA	NA	NA	V	NA	NA	NA	NA	V	NA
108	IV	NA	NA	NA	NA	V	NA	NA	NA	NA	V	NA

RCCP Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
 PVC Polyvinyl Chloride (PVC) Pipe
 CPVC Corrugated Polyvinyl Chloride (PVC) Pipe with a Smooth Interior

X This material may be used for the given pipe diameter and fill height.

NA This material is Not Acceptable for the given pipe diameter and fill height.

** May be used if Bureau of Materials and Physical Research approves and with manufacturer's certification.

Note RCCP Class V - 3160D, etc. shall be furnished according to AASHTO M 170 Section 6. These loads are D loads to produce a 0.01 in. crack.

STORM SEWERS (metric) KIND OF MATERIAL PERMITTED AND STRENGTH REQUIRED FOR A GIVEN PIPE DIAMETER AND FILL HEIGHT OVER THE TOP OF THE PIPE											
Nom. Dia.	Type 5 Fill Height: Greater than 6 m, not exceeding 7.5 m				Type 6 Fill Height: Greater than 7.5 m, not exceeding 9 m				Type 7 Fill Height: Greater than 9 m, not exceeding 10.5 m		
	RCCP Class	PVC	CPVC	PVCPW/PVCPW-794	RCCP Class	PVC	CPVC	PVCPW/PVCPW-794	RCCP Class	PVC	PVCPW
250	NA	X	**	NA	NA	X	**	NA	NA	X	X
300	V-150D	X	X	X	V-180D	X	X	X	V-190D	X	X
375	V-145D	X	X	X	V-160D	X	X	X	V-170D	X	X
450	V	X	X	X	V-150D	X	NA	NA	V-160D	X	X
525	V	X	X	X	V	X	NA	NA	V-150D	X	X
600	V	X	X	X	V	X	NA	NA	V	X	X
675	V	X	NA	NA	V	X	NA	NA	V	X	X
750	V	X	NA	NA	V	X	NA	NA	V	X	X
825	V	X	NA	NA	V	X	NA	NA	V	X	X
900	V	X	NA	NA	V	X	NA	NA	V	X	X
1050	V	NA	NA	NA	V	NA	NA	NA	V	NA	NA
1200	V	NA	NA	NA	V	NA	NA	NA	V	NA	NA
1350	V	NA	NA	NA	V	NA	NA	NA	V	NA	NA
1500	V	NA	NA	NA	V	NA	NA	NA	V	NA	NA
1650	IV	NA	NA	NA	V	NA	NA	NA	V	NA	NA
1800	IV	NA	NA	NA	V	NA	NA	NA	V	NA	NA
1950	IV	NA	NA	NA	V	NA	NA	NA	V	NA	NA
2100	IV	NA	NA	NA	V	NA	NA	NA	V	NA	NA
2250	IV	NA	NA	NA	V	NA	NA	NA	V	NA	NA
2400	IV	NA	NA	NA	V	NA	NA	NA	V	NA	NA
2550	IV	NA	NA	NA	V	NA	NA	NA	V	NA	NA
2700	IV	NA	NA	NA	V	NA	NA	NA	V	NA	NA
RCCP	Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe										
PVC	Polyvinyl Chloride (PVC) Pipe										
CPVC	Corrugated Polyvinyl Chloride (PVC) Pipe with a Smooth Interior										
X	This material may be used for the given pipe diameter and fill height.										
NA	This material is Not Acceptable for the given pipe diameter and fill height.										
**	May be used if Bureau of Materials and Physical Research approves and with manufacturer's certification.										
Note	RCCP Class V - 3160D, etc. shall be furnished according to AASHTO M 170 Section 6. These loads are D loads to produce a 0.01 in. crack.										

CONSTRUCTION REQUIREMENTS

550.04 Excavation and Foundation. Trenches shall be excavated to an elevation 4 in. (100 mm) below the bottom of the pipe and to the following widths.

Trench Depth/Protection	Required Trench Width On Each Side of the Pipe
5 ft (1.5 m) and less, without protection	9 in. (225 mm)
5 ft (1.5 m) and less, with protection	18 in. (450 mm)
Greater than 5 ft (1.5 m)	18 in. (450 mm)

The trench shall be excavated so that vertical faces are maintained at least to the elevation of the top of pipe. For trench depths greater than 5 ft (1.5 m), trench protection shall be utilized according to the applicable standards for work place safety. The Contractor shall provide to the Engineer, in writing, his/her procedures for fulfilling the safety requirements for trench protection.

If a water main is encountered during storm sewer construction, the requirements of the IEPA shall govern the horizontal and vertical separation of the water main from the storm sewer.

Well compacted aggregate, at least 4 in. (100 mm) in depth below the pipe, shall be placed for the entire width of the trench and length of the pipe; except when the storm sewer outlets from an embankment or natural ground, the last 3 ft (1 m) of the pipe shall be bedded in impervious material. The aggregate and impervious material shall be compacted by mechanical means to the satisfaction of the Engineer.

When pipe having bells or hubs is used, cross trenches not more than 2 in. (50 mm) wider than the bell or hub shall be excavated to provide uniform bearing along the length of the pipe.

If the excavation has been made deeper than necessary, the foundation shall be brought to the proper grade by the addition of well compacted bedding material.

Where a firm foundation is not encountered at the grade established due to soft, spongy, or otherwise unsuitable soil, unless other special construction methods are called for in the contract, all such unsuitable soil under the pipe and for the width of the trench shall be removed and replaced with well-compacted bedding material.

Where rock, in either ledge or boulder formation, is encountered, it shall be removed to an elevation at least 8 in. (200 mm) below the bottom of the pipe and replaced with a cushion of well compacted bedding material.

All excavated material not needed on the work shall be disposed of according to Article 202.03.

550.05 Plugging Existing Sewers and Drains. Abandoned sewers and drains, as designated by the Engineer, shall be plugged with Class SI concrete, or brick and suitable mortar, to the satisfaction of the Engineer.

This work will not be paid for separately, but shall be considered as included in the contract unit price bid for the storm sewer items or in the absence of such items for earth excavation.

550.06 Laying Sewer Pipe. The trench shall be kept free from water while the sewer is being placed and until the joint has been sealed. The laying of pipes shall be started at the outlet end with the spigot ends pointing in the direction of flow, and shall proceed toward the inlet end with pipes abutting and true to line and grade. The flow line at the outlet end of the pipe shall be at least 6 in. (150 mm) above the flow line of the open ditch.

When an end treatment, pipe tee, or elbow is required, it will be specified on the plans. End treatments shall be according to Article 542.07. Pipe tees and elbows shall be according to Article 542.08.

The ends of pipes shall be carefully cleaned before the pipes are lowered into the trenches, and the pipes shall be lowered so as to avoid unnecessary handling in the trench.

As each length of pipe is laid, the mouth of the pipe shall be properly protected to prevent the entrance of earth or the bedding material. The pipes shall be fitted and matched so that when laid in the work they will form a sewer with a smooth, uniform invert. If reinforced concrete pipe is used, the word "Top" or "Bottom" may be stenciled on the inside of the pipe sections. All concrete pipe so marked shall be placed as indicated by these marks. Each section of pipe shall be pushed or pulled to the section in place to ensure tight joints. Pipe having a diameter greater than 42 in. (1050 mm) shall be set or "brought home" with a winch, come-a-long, or other positive means.

All joints in concrete sewer pipe shall be sealed with rubber gaskets, preformed flexible joint sealants, mastic joint sealer, or external sealing bands. When mastic joint sealer is used, it shall be applied according to the manufacturer's recommendations and the material shall completely fill the joint after the pipes have been brought together. After each joint is sealed, it shall be wiped clean on the inside. Handling holes in concrete pipe shall be filled with a precast concrete plug and sealed with mastic or mortar; or filled with a polyethylene plug. The plug shall not project beyond the inside surface after installation.

PVC and PE pipes shall be joined according to the manufacturer's specifications.

550.07 Backfilling. As soon as the condition of the pipe will permit, the entire width of the trench shall be backfilled with aggregate to a height of at least the center of the pipe; except when the storm sewer outlets from an embankment or natural ground, the last 3 ft (1 m) of the pipe shall be backfilled with impervious material. The backfill material shall be placed longitudinally along the pipe. The elevation of the backfill material on each side of the pipe shall be the same. The space under the pipe shall be completely filled. The backfill material shall be placed in 8 in. (200 mm) lifts, loose measurement, and compacted by mechanical means to the satisfaction of the Engineer.

When using flexible pipe, as listed in the first table of Article 550.03, the aggregate shall be continued to a height of at least 1 ft (300 mm) above the top of the pipe and compacted to a minimum of 95 percent of standard lab density by mechanical means.

The installed pipe and its embedment shall not be disturbed when using movable trench boxes and shields, sheet pile, or other trench protection.

The remainder of the trench shall be backfilled to the natural line or finished surface as rapidly as the condition of the sewer will permit. The backfill material shall consist of suitable excavated material from the trench or trench backfill as herein specified. All backfill material shall be deposited in such a manner as not to damage the sewer. The filling of the trench shall be carried on simultaneously on both sides of the pipe.

The backfill material for trenches made in the subgrade of the proposed improvement, and trenches where the inner edge of the trench is within 2 ft (600 mm) of the proposed edge of pavement, curb, gutter, curb and gutter, stabilized shoulder or sidewalk, shall be trench backfill

All backfill material shall be deposited and compacted as specified in Method 1, 2, or 3 below. The method used shall be the choice of the Contractor. If the method used does not produce results satisfactory to the Engineer, the Contractor will be required to alter or change the method being used.

When trench backfill is used with Method 1, the lifts shall not exceed 8 in. (200 mm) in depth, loose measurement, and each lift shall be compacted to 85 percent of standard lab density by mechanical means. When trench backfill is used with Method 2 or 3, gradations CA 6 and CA 10 will not be allowed.

- (a) Method 1. The material shall be deposited in uniform lifts not exceeding 12 in. (300 mm) in depth, loose measurement, and each lift shall be compacted by mechanical means to the satisfaction of the Engineer.
- (b) Method 2. The material shall be deposited in uniform lifts not exceeding 12 in. (300 mm) thick, loose measurement, and each lift shall be either inundated or deposited in water.
- (c) Method 3. The trench shall be backfilled with loose material, and settlement secured by introducing water through holes jetted into the backfill to a point approximately 2 ft (600 mm) above the top of the pipe. The holes shall be spaced as directed by the Engineer but shall be no farther than 6 ft (2 m) apart.

The water shall be injected at a pressure just sufficient to sink the holes at a moderate rate of speed. The pressure shall be such that the water will not cut cavities in the backfill material nor overflow the surface. If water does overflow the surface, it shall be drained into the jetted holes by means of shallow trenches.

Water shall be injected as long as it will be absorbed by the backfill material and until samples taken from test holes in the trench show a satisfactory

moisture content. The Contractor shall bore the test holes not more than 50 ft (15 m) apart and at such other locations in the trench designated by the Engineer. As soon as the water soaking has been completed, all holes shall be filled with soil and compacted by ramming with a tool approved by the Engineer.

Backfill material which has been water soaked shall be allowed to settle and dry for at least ten days before any surface course or pavement is constructed on it. At the end of the settling and drying period, the crusted top of the backfill material shall be scarified and, if necessary, sufficient backfill material added, as specified in Method 1, to complete the backfilling operations.

In lieu of suitable excavated material or trench backfill, the Contractor may, at no additional cost to the Department, backfill the entire trench with controlled low-strength material according to Section 593.

When sheeting and bracing have been used, sufficient bracing shall be left across the trench as the backfilling progresses to hold the sides firmly in place without caving or settlement. This bracing shall be removed as soon as practicable. Any depressions which may develop within the area involved in the construction operation due to settlement of the backfilling material shall be filled in a manner meeting the approval of the Engineer.

When the Contractor constructs the trench with sloped or benched sides, backfilling for the full width of the excavation shall be as herein before specified, except no additional compensation will be allowed for trench backfill material required outside the vertical limits of the specified trench width.

Whenever excavation is made for installing sewer pipe across earth shoulders or private property, the topsoil disturbed by excavation operations shall be replaced as nearly as possible in its original position, and the whole area involved in the construction operations shall be left in a neat and presentable condition.

550.08 Deflection Testing for Storm Sewers. All PVC and PE storm sewers shall be tested for deflection not less than 30 days after the pipe is installed and the backfill compacted. The testing shall be performed in the presence of the Engineer.

For PVC and PE storm sewers with diameters 24 in. (600 mm) or smaller, a mandrel drag shall be used for deflection testing. For PVC and PE storm sewers with diameters over 24 in. (600 mm), deflection measurements other than by a mandrel drag shall be used.

Where the mandrel is used, the mandrel shall be furnished by the Contractor and pulled by hand through the pipeline with a suitable rope or cable connected to each end. Winching or other means of forcing the deflection gauge through the pipeline will not be allowed.

The mandrel shall be of a shape similar to that of a true circle enabling the gauge to pass through a satisfactory pipeline with little or no resistance. The mandrel shall be of a design to prevent it from tipping from side to side and to prevent debris build-up from occurring between the channels of the adjacent fins or legs during operation. Each end of the core of the mandrel shall have fasteners to which the pulling cables

can be attached. The mandrel shall have nine, various sized fins or legs of appropriate dimension for various diameter pipes. Each fin or leg shall have a permanent marking that states its designated pipe size and percent of deflection allowable.

The outside diameter of the mandrel shall be 95 percent of the base inside diameter. For all PVC pipe and PE Profile Wall pipe, the base inside diameter shall be defined using ASTM D 3034 methodology. For all other PE pipe, the base inside diameter shall be defined as the average inside diameter based on the minimum and maximum tolerances specified in the corresponding ASTM or AASHTO material specifications.

If the pipe is found to have a deflection greater than that specified, that pipe section shall be removed, replaced, and retested.

550.09 Method of Measurement. Storm sewers will be measured for payment in place in feet (meters). When the storm sewer enters a manhole, inlet, or catch basin, the measurement will end at the inside wall of the manhole, inlet or catch basin. Allowance will be made for the length of pipe necessary to permit the pipe to meet the sides of the manhole. No payment for storm sewer will be made through an inlet or manhole where the inlet or manhole is paid for as a separate item. However, when the storm sewer is continuous and the inlet is constructed on top of the storm sewer, the measurement will be from end to end of storm sewer with a deduction made for the tee section which is paid for separately.

Trench backfill will be measured for payment according to Article 208.03.

Excavation in rock will be measured for payment according to Article 502.12.

550.10 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for STORM SEWERS, of the class, type, and diameter specified, and of the kind of material when specified.

Trench backfill will be paid for according to Article 208.04.

Excavation in rock will be paid for according to Article 502.13.

Removal and replacement of unsuitable material below plan bedding grade will be paid for according to Article 109.04.

End treatments, pipe tees, and elbows will be paid for according to Article 542.11.

SECTION 551. STORM SEWER REMOVAL AND INSTALLATION

551.01 Description. This work shall consist of the removal and/or installation of storm sewers, including laterals.

551.02 Materials. New materials shall be according to Articles 550.02 and 550.03.

CONSTRUCTION REQUIREMENTS

551.03 Removal. Existing storm sewers shall be removed so that all pipe considered suitable by the Engineer for future use shall be salvaged. The location and manner of storage of salvaged material shall be as directed by the Engineer.

Any of the material having salvage value which has been damaged by the Contractor shall be replaced with new pipe of the same kind and size. Material not suitable for salvage shall be disposed according to Article 202.03.

Excavation of trenches shall be performed according to the applicable requirements of Article 550.04. Backfill of trenches shall be performed according to the applicable requirements of Article 550.07.

551.04 Installation. Suitable pipe salvaged from storm sewer removal shall be used when available. When salvaged pipe is available for use, any new material required shall be of the same kind as the salvaged pipe.

Storm sewer installation shall be performed according to the applicable requirements of Section 550.

551.05 Method of Measurement. This work will be measured for payment according to Article 550.09.

Excavation in rock will be measured for payment according to Article 502.12.

Trench backfill for storm sewer removal will be measured for payment according to Article 208.03, except an addition will be made for one-half of the volume of the pipe removed.

Trench backfill for storm sewer installation will be measured for payment according to Article 208.03.

551.06 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for STORM SEWER REMOVAL and/or STORM SEWER INSTALLATION, of the diameter specified.

The furnishing of new pipe, except for replacement of pipe damaged by the Contractor, will be paid for according to Article 109.04.

Excavation in rock will be paid for according to Article 502.13.

Trench backfill will be paid for according to Article 208.04.

Removal and replacement of unsuitable material below plan bedding grade will be paid for according to Article 109.04.

SECTION 552. STORM SEWERS JACKED IN PLACE

552.01 Description. This work shall consist of furnishing and installing, by jacking, storm sewers of the required inside diameter at locations shown on the plans.

552.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Reinforced Concrete Culvert, Storm Drain and Sewer Pipe (Note 1)	1042
(b) Reinforced Concrete Elliptical Culvert, Storm Drain and Sewer Pipe (Note 1)	1042
(c) Grout	1024.01
(d) Reinforcement Bars and Welded Wire Fabric	1006.10

Note 1. Tongue and Groove Type Joint. Not less than a Class IV Pipe.

552.03 Traffic Control. The road shall be kept open to traffic according to Article 701.17(d)(3).

CONSTRUCTION REQUIREMENTS

552.04 General. Storm sewers, of the type and size specified, shall be jacked in a continuous operation. The construction may be accomplished by jacking the storm sewer, or if the Contractor elects, a metal liner of sufficient strength and size first, then the storm sewer installed inside the liner. If the liner is used, it shall remain in place to support the embankment, and the voids between the liner and the sewer pipe shall be completely filled with sand or grout mixture as approved by the Engineer. The grout mixture shall be one part cement and two parts sand mixed with water. The diameter of the metal liner, if used, shall not exceed the outside diameter of the storm sewer by more than 6 in. (150 mm).

The Contractor may shorten the length of storm sewer to be jacked by open cutting and sheeting, shoring or bracing the excavation outside the roadway limits. No open cutting shall be permitted inside the shoulder lines. If continuous jacking operation cannot be maintained, the Contractor shall take the necessary precautions for not allowing the jacked pipe to freeze in place.

All sheeting, bracing, shoring, jacking frame, guide rails, backstop, shields, sleeves, and other materials necessary for the complete installation of the storm sewer shall be of sufficient strength to support the loads that are to be imposed on them.

The types, sizes, and number of jacks, jacking pit, and other equipment used shall be such as to exert sufficient force to overcome the greatest resistance to be encountered, considering both weight of the pipe or liner and the friction on its

exterior surface. Lubricants, if required, may be used to decrease the frictional resistance on the exterior surface of the pipe being jacked. Suitable lubricants may be applied directly to the surface or through 1/2 in. (13 mm) nipples through holes drilled in the cutting shield at the lead pipe.

Care shall be taken in arranging the jacking equipment and struts to ensure that thrust is applied parallel with the centerline of the pipe or liner or as approved by the Engineer. A jacking head or collar shall be used to apply pressure from the jack to the pipe or liner. Pressure applied with the metal of the jack in direct contact with concrete pipe will not be permitted.

A cutting edge at least 1/2 in. (13 mm) greater in diameter than the pipe or liner being jacked shall be provided for the leading pipe or liner. The upper half of the cutting edge shall project beyond the pipe or liner end to support the embankment. Excavation within the jacked pipe or liner shall be performed in such a manner as to not increase the excavated diameter larger than the pipe or liner being jacked. Excavation shall not be carried beyond the end of the cutting edge of the pipe or liner. Any holes provided in the lead pipe to attach the cutting edge shall be properly filled with plug and mastic as approved by the Engineer after completion of the jacking operation and removal of cutting edge.

552.05 Joints. As each succeeding pipe section is placed against the previously jacked pipe, a 1/2 in. (13 mm) manila rope or other suitable material shall be inserted throughout the entire groove of the joint and set in place with asphalt mastic. The opening on the inside of the pipe shall be mortared with a mixture composed of one part cement to three parts sand, by volume, based on dry materials, after the complete sewer has been jacked in place. Any other method of jointing must be approved by the Engineer prior to the start of construction.

552.06 Accuracy of Placement. The alignment and elevation of the forward end of the pipe shall be checked at regular intervals as work proceeds and appropriate measures immediately taken to correct any observed deviation. When the Contractor elects to jack a metal liner prior to installing the storm sewer, all earth and other foreign material shall be removed from inside the liner. The storm sewer sections shall be installed by jacking the sections through the liner.

552.07 Method of Measurement. This work will be measured for payment in place in feet (meters).

Excavation in rock will be measured for payment according to Article 502.12.

552.08 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for STORM SEWERS JACKED IN PLACE, of the diameter specified.

Excavation in rock will be paid for according to Article 502.13.

UTILITIES**SECTION 560. CAST IRON SOIL PIPE**

560.01 Description. This work shall consist of constructing a cast iron soil pipe.

560.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Cast Iron Soil Pipe	1006.20

CONSTRUCTION REQUIREMENTS

560.03 General. Construction requirements shall be according to Section 550 with the following exceptions.

The pipe shall be laid with its spigot end lacking 1/4 in. (6 mm) of being driven full into the bell. Gaskets of clean, sound hemp yarn braided or twisted and tightly driven shall be used to pack the joints, followed by caulking with pure soft lead of the best quality for the purpose, so as to make a tight and permanent joint. All pipes shall be carefully cleaned before laying, and shall be left clean and in working order. The pipe shall have a solid bearing throughout its entire length. If it becomes necessary to cut the pipe, it shall be cut in such a manner that the ends will be square with the axis of the pipe.

560.04 Method of Measurement. This work will be measured for payment in place in feet (meters).

Excavation in rock will be measured for payment according to Article 502.12.

Trench backfill will be measured for payment according to Article 208.03.

560.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for CAST IRON SOIL PIPE, of the diameter specified.

Excavation in rock will be paid for according to Article 502.13.

Trench backfill will be paid for according to Article 208.04.

SECTION 561. WATER MAIN

561.01 Description. This work shall consist of constructing a water main.

561.02 Materials. Materials shall be as shown in the contract.

CONSTRUCTION REQUIREMENTS

561.03 General. The construction of water mains, including protection from sewers, pressure testing, and disinfection, shall be according to the "Standard Specifications for Water & Sewer Main Construction in Illinois", except as follows.

- (a) **Excavation and Foundation.** This work shall be according to the applicable requirements of Article 550.04.
- (b) **Backfilling.** This work shall be according to Article 550.07, except backfilling shall not be done in freezing weather nor made with frozen material.

Backfilling around joints shall not be performed until the pressure testing has been completed.

561.04 Method of Measurement. This work will be measured for payment in place in feet (meters). The length measured will include stops, fittings, and valves.

Excavation in rock will be measured for payment according to Article 502.12.

Trench backfill will be measured for payment according to Article 208.03.

561.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for WATER MAIN, of the diameter specified.

Excavation in rock will be paid for according to Article 502.13.

Trench backfill will be paid for according to in Article 208.04.

SECTION 562. WATER SERVICE LINE

562.01 Description. This work shall consist of constructing a water service line.

562.02 Materials. Materials shall be as shown in the contract.

CONSTRUCTION REQUIREMENTS

562.03 General. Work shall be performed according to the Illinois Plumbing Code or local codes where applicable, except as follows.

Any excavation required shall be only sufficient to install the water service line. Surplus material shall be disposed of according to Article 202.03.

The applicable requirements of Article 550.07 shall govern the backfilling, except that backfilling shall not be done in freezing weather nor made with frozen material.

562.04 Method of Measurement. This work will be measured for payment in place in feet (meters). The length measured will include stops, fittings, and valves.

Excavation in rock will be measured for payment according to Article 502.12.

Trench backfill will be measured for payment according to Article 208.03.

562.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for WATER SERVICE LINE, of the internal diameter specified.

Excavation in rock will be paid for according to Article 502.13.

Trench backfill will be paid for according to Article 208.04.

SECTION 563. ADJUSTING SANITARY SEWERS AND WATER SERVICE LINES

563.01 Description. This work shall consist of adjusting sanitary sewers and water service lines.

563.02 Materials. Materials shall be as shown in the contract. Materials for replacement shall be new and of the same kind as, or equal to, the material being replaced.

CONSTRUCTION REQUIREMENTS

563.03 General. When a Sanitary District, Municipality, or Water District has jurisdiction of a sanitary sewer or water service line, the work shall be performed as prescribed by the Sanitary District, Municipality, or Water District and shall meet the approval of its Engineer.

Materials suitable for reuse in the opinion of the Engineer shall be carefully removed to prevent damage. Such materials damaged by the Contractor shall be replaced. All material removed and not reused shall become the property of the Contractor.

Surplus material shall be disposed of according to Article 202.03.

563.04 Adjusting Sanitary Sewers. Adjustment of sanitary sewers shall be according to the "Standard Specifications for Water and Sewer Main Construction in Illinois". The applicable requirements of Article 550.07 shall govern the backfilling, except that backfilling shall not be done in freezing weather nor made with frozen material.

Art. 563.05 Adjusting Sanitary Sewers and Water Service Lines

563.05 Adjusting Water Service Lines. The work necessary to adjust water service lines shall be performed according to Article 562.03.

Any water service line, other than copper, which is or will be under a base or surface course and which requires adjustment, shall be replaced with copper pipe according to the requirements of Article 1006.33.

563.06 Method of Measurement. This work will be measured for payment in place in feet (meters). The length measured will include stops, fittings, and valves.

Excavation in rock will be measured for payment according to Article 502.12.

Trench backfill will be measured for payment according to Article 208.03.

563.07 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for ADJUSTING SANITARY SEWERS, (8 IN. (200 MM) DIAMETER OR LESS); ADJUSTING SANITARY SEWERS, (OVER 8 IN. (200 MM) DIAMETER); and ADJUSTING WATER SERVICE LINES.

Excavation in rock will be paid for according to Article 502.13.

Trench Backfill will be paid for according to Article 208.04.

The furnishing of materials, except for replacement of materials damaged by the Contractor, will be paid for according to Article 109.04.

SECTION 564. MOVING FIRE HYDRANTS

564.01 Description. This work shall consist of moving and adjusting existing fire hydrants, with auxiliary valves when applicable, which interfere with the construction of the proposed improvement.

564.02 Materials. Materials shall be as shown in the contract. Materials for replacement shall be new and of the same kind as, or equal to, the material being replaced.

CONSTRUCTION REQUIREMENTS

564.03 General. The work shall be performed in a manner approved by the Engineer of the Municipality or the Water District.

Fire Hydrants shall be set on a firm foundation and shall be thrust blocked. Thrust blocking shall consist of Class SI concrete cast against the fittings and the undisturbed earth on the side where the thrust is expected to occur. A minimum of 1/4 cu yd (0.2 cu m) of concrete shall be used for the thrust block. The dimensions of the thrust block shall be determined by the Engineer. Blocking shall be placed such that the pipe, fittings and joints shall be accessible for future repair.

Upon completion of relocating or adjusting the fire hydrant, it shall be tested and disinfected according to Article 561.03.

The hole formed by the removal of a fire hydrant and the remaining excavated area around the relocated fire hydrant shall be backfilled with fine aggregate.

Surplus material shall be disposed of according to Article 202.03.

Any fire hydrant damaged by the Contractor shall be repaired.

564.04 Basis of Payment. This work will be paid for at the contract unit price per each for FIRE HYDRANTS TO BE MOVED.

SECTION 565. MOVING DOMESTIC METER VAULTS AND WATER SERVICE BOXES

565.01 Description. This work shall consist of moving domestic meter vaults and water service boxes.

565.02 Materials. Materials shall be as shown in the contract. Materials for replacement shall be new and of the same kind as, or equal to, the material being replaced.

CONSTRUCTION REQUIREMENTS

565.03 General. The work shall be performed in a manner approved by the Engineer of the Municipality or the Water District.

The hole formed by the removal of the domestic meter vault or water service box shall be backfilled with fine aggregate.

Surplus material shall be disposed of according to Article 202.03.

Any domestic meter vault or water service box, including the stop cocks, which are damaged by the Contractor, shall be repaired.

565.04 Basis of Payment. This work will be paid for at the contract unit price per each for DOMESTIC METER VAULTS TO BE MOVED or DOMESTIC WATER SERVICE BOXES TO BE MOVED.

MISCELLANEOUS

SECTION 580. MEMBRANE WATERPROOFING FOR RAILWAY STRUCTURES

580.01 Description. This work shall consist of furnishing, transporting and placing all materials required to construct a membrane waterproofing system on railway structures.

The membrane waterproofing shall be of the bituminous or butyl rubber type as specified on the plans.

580.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Waterproofing Materials (Note 1)	1060
(b) Fine Aggregate	1003.05

Note 1. The bitumen used shall be asphalt. The bitumen for mopping and for the protective cover shall be the same type as that with which the fabric is treated.

CONSTRUCTION REQUIREMENTS

580.03 General. Surfaces to be waterproofed shall be smooth and free from projections which might damage the waterproofing membrane and there shall be no depressions in horizontal surfaces of the finished waterproofing. Projections or depressions on the surface on which the membrane is to be applied that may cause damage to the membrane shall be removed or filled as directed by the Engineer. The surface shall be cleaned of dust, dirt, grease, and loose particles, and shall be dry before the waterproofing is applied. Concrete surfaces shall not be waterproofed until a period of at least seven days has elapsed after the placing of the concrete, unless otherwise approved by the Engineer.

There shall be no depressions or pockets in horizontal surfaces of the finished waterproofing. The membrane shall be carefully turned into drainage fittings. Special care shall be taken to make the waterproofing effective along the sides and ends of girders and at stiffeners, gussets, and all other plates where the membrane terminates.

Bituminous membrane waterproofing shall not be applied when the atmospheric temperature is below 50 °F (10 °C) and butyl rubber membrane shall not be applied when the atmospheric temperature is below 10 °F (-12 °C), without written permission of the Engineer.

Surfaces of concrete or steel that are to be waterproofed shall be given one coat of Asphalt Primer (RC-70) before the first mopping of Asphalt (AWP), except that at construction and expansion joints where insulation is to be used, the surfaces shall not be coated with primer. The primer shall be applied to the surface in a uniform coating and may be applied without heating. A minimum of 1 gal (4 L) of primer per 100 sq ft (10 sq m) of surface shall be used. The priming coat shall be applied at

least 24 hours before applying the waterproofing membrane and it shall be dry before the first mopping of bitumen is applied.

The primer shall be omitted for a width of 9 in. (225 mm) on each side of construction and expansion joints and a strip of insulating paper 18 in. (450 mm) wide shall be laid thereon before the waterproofing is applied. Insulating paper shall be a waterproof paper weighing not less than 10 lb/100 sq ft (0.5 kg/sq m).

Expansion joints and grooves shall be dry and clean; and shall be filled with plastic cement. Expansion joints and grooves filled with plastic cement shall be overfilled to allow for shrinkage.

580.04 Membrane Application. Bituminous and butyl rubber membranes shall be applied as specified.

- (a) Bituminous Membrane. On surfaces that are vertical, or nearly so, the strips of fabric shall be laid vertically or with the slope; on other surfaces the strips shall be laid horizontally, beginning at the lowest part of the surface to be waterproofed. Sufficient fabric shall be allowed for anchorage at the upper edge of the surface to be waterproofed.

Surfaces to be waterproofed shall be mopped in sections. While the first mopping of bitumen is still hot, a strip of fabric shall be laid on the mopping and pressed into place. Each mopping thereafter shall be applied so that it will completely cover and seal the fabric. The amount of bitumen used for each mopping shall be not less than 4 1/2 gal/100 sq ft (1.8 L/sq m) of surface. The bitumen for mopping shall be heated to a temperature which will permit uniform application. Asphalt shall not be heated above a temperature of 350 °F (175 °C).

Asphalt (AWP) shall be used for mopping asphalt saturated cotton fabric.

Application of bituminous membrane shall be started by mopping a section of the surface 2 in. (50 mm) wider than 1/3 of the width of fabric. On this hot mopping, a 1/3 width of fabric shall be laid. The top surface of this fabric and an adjacent section of the surface 2 in. (50 mm) wider than 1/3 width of fabric shall then be mopped. On this hot mopping, a 2/3 width of fabric shall be laid completely covering the first strip. The top surface of this fabric and an adjacent section of the surface 2 in. (50 mm) wider than 1/3 width of fabric shall then be mopped. On this hot mopping shall be laid a full width of fabric completely covering the first and second strips. The top surface of this fabric and adjacent section, the width of 1/3 width of the fabric, shall then be mopped. On this hot mopping, the second full strip of fabric shall be laid lapping the first 1/3 width of the fabric at least 2 in. (50 mm). Thereafter, full widths of fabric shall be laid in hot moppings of bitumen and in such manner that each strip will lap the third preceding strip at least 2 in. (50 mm). Side laps shall be not less than 2 in. (50 mm) and end laps not less than 12 in. (300 mm).

The bituminous membrane shall be free from punctures, pockets or folds, and patching shall not be done without the permission of the Engineer. Where patching is permitted for defective waterproofing, the first ply shall

extend at least 12 in. (300 mm) beyond the defective portion. The second and each succeeding ply of the patch shall extend at least 3 in. (75 mm) beyond the preceding ply.

The work shall be regulated so that at the end of the day all fabric that has been laid shall have received the final coat of bitumen, except that the fabric for making the lap shall not be mopped with bitumen until the joint is to be completed. With the approval of the Engineer, spraying will be permitted in lieu of mopping.

- (b) Butyl Rubber Membrane. Butyl rubber membrane sheets shall be laid and secured in a hot mopping of bitumen applied over the primed surfaces. When the surface has been primed using RC-70, the mopping shall be with asphalt (AWP). An adhesive, compatible to the membrane and other materials, may be used in lieu of the hot mopping of bitumen, at the option of the Contractor. If adhesive is used, it shall be applied to the areas to be waterproofed in a thin layer with a squeegee at a rate of 1 gal/100 sq ft (0.4 L/sq m).

Membrane sheets shall first be positioned and drawn tight without stretching. Half of the membrane sheet shall then be uniformly rolled up in a direction away from the starting edge or subsequent splice. The bitumen or adhesive shall now be applied to the exposed area. If adhesive is used, it shall be allowed to dry so as not to stick to a dry finger touch. The membrane shall then be unrolled and pressed firmly and uniformly in place, using care to avoid trapping air. The same procedure shall be used for the remaining half of the membrane sheet. Wrinkles and buckles shall be avoided. Each succeeding sheet shall be positioned to fit the previously installed sheet and spliced.

Splices shall be of tongue-and-groove or lap type. All seam, lap, and splice areas shall be cleaned with heptane, hexane, toluene, trichlorethylene, or white gasoline, using a clean cloth, mop, or similar synthetic cleaning device. Rubber cement shall be spread continuously on seam, lap, and splice areas at a uniform rate of not less than 2 gal/100 sq ft (0.8 L/sq m). After the rubber cement is allowed to dry until it will not stick to a dry finger touch, butyl gum tape shall be applied to the cemented area of membrane. The tape shall be extended at least 1/8 in. (3 mm) beyond edges of splice and lap areas. The tape shall be rolled or pressed firmly into place so full contact is obtained. Bridging and wrinkles shall be avoided. Corner splices shall be reinforced with two continuous layers of rubber membrane over one layer of butyl tape.

All projecting pipe, conduits, and sleeves passing through butyl rubber membrane waterproofing shall be flashed with prefabricated or field-fabricated boots or fitted coverings, as necessary to provide watertight construction. Butyl gum tape shall be used between layers of rubber membrane.

Any holes in the membrane sheeting shall be patched with a minimum overlap of 4 in. (100 mm) and according to the manufacturer's instructions.

During construction, care shall be exercised to prevent damage to the membrane by workers or equipment.

580.05 Protective Cover. The protective cover shall be placed over the membrane as soon as practicable after the membrane has been laid. Dirt and other foreign material shall be removed from the surface of the membrane before the protective cover is placed.

At expansion joints of decks protected with butyl rubber membrane, a strip of anti-bonding paper 18 in. (450 mm) wide shall be laid above and below the membrane before the protective cover is applied.

One of the following methods of protection shall be used.

- (a) A layer of asphalt plank not less than 1 1/4 in. (30 mm) thick laid in a mopping of asphalt with all joints filled with asphalt.
- (b) A layer or layers of asphaltic panels not less than 3/4 in. (20 mm) in total thickness.

For bituminous membrane, the asphalt plank protection shall be laid in hot asphalt (AWP). The asphalt shall be applied at the rate of not less than 5 gal/100 sq ft (2 L/sq m) of surface. As successive planks are laid, the edges and ends of adjacent planks already laid shall be coated heavily with hot asphalt. The planks shall be laid tight against those previously laid so that the asphalt will completely fill the joints and be squeezed out at the top. After all planks are laid, any joints not completely filled shall be filled with hot asphalt. The ends of adjacent planks shall be staggered.

For butyl rubber membrane, the asphalt plank shall be laid in a coating of bonding adhesive. The bonding adhesive shall be the same as that used for securing the membrane to the deck. The adhesive shall be applied at a rate of not less than 1 gal/100 sq ft (0.4 L/sq m). Voids between the joints shall be filled with a compatible material.

Asphaltic panels are available in various thicknesses. To obtain the thickness of 3/4 in. (20 mm) required, the recommended application is in two layers with the joints staggered. The panels shall be laid tight jointed with an approved adhesive. For bituminous membrane, the asphaltic panels shall be laid in hot asphalt (AWP) and for butyl rubber membrane, the panels shall be laid in a coating of bonding adhesive. The application rate shall be the same as previously specified for asphalt planks. Any voids between the panels shall be filled with a material compatible to both the membrane and the panel.

When asphaltic panels are used as a protective cover, a 2 in. (50 mm) layer of fine aggregate shall be placed over the panels as a cushion prior to placement of ballast. The cost of this cushion shall be included in the bid price for membrane waterproofing.

Art. 580.06

Waterproofing Membrane System

580.06 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. The membrane waterproofing will be measured for payment in place, and the area computed in square feet (square meters). The area for measurement will include only the surface of the membrane waterproofing covered with a protective cover.

580.07 Basis of Payment. This work will be paid for at the contract unit price per square foot (square meter) for MEMBRANE WATERPROOFING.

SECTION 581. WATERPROOFING MEMBRANE SYSTEM

581.01 Description. This work shall consist of furnishing and placing a waterproofing membrane system over a properly prepared concrete bridge deck prior to placing of the hot-mix asphalt (HMA) surface course.

581.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Water	1002
(b) Waterproofing Membrane System (Note 1)	1061
(c) Grout	1024.01

Note 1. The waterproofing membrane system shall consist of a penetrating primer, a built-up coal tar pitch emulsion membrane with two plies of coated glass fabric, and a 1/2 in. (13 mm) thick asphalt sand seal protection layer.

CONSTRUCTION REQUIREMENTS

581.03 General. All methods employed in performing the work and all equipment, tools, and machinery used for handling materials and executing any part of the work shall be subject to approval of the Engineer before the work is started, and whenever found unsatisfactory, shall be changed or improved as required. All equipment, tools, machinery, and containers used shall be kept clean and maintained in a satisfactory condition.

581.04 Preparation of Concrete Deck. All surfaces which are to be covered shall be thoroughly cleaned by the use of air jets, water jets, mechanical sweeper, hand brooms, or other approved methods, or as required by the Engineer until the surface is free of all sand, clay, dust, salt deposits, and all loose or foreign matter. Any accumulations of oil or grease shall be scraped off the surface of the roadway after which those areas shall be cleaned with a strong caustic solution, the residue of which shall be thoroughly flushed away with clean water before application of the primer.

All cleaned areas shall be primed without delay as soon as they are dry. All dust and dirt shall be blown off with air jets immediately preceding application of primer. Any unusually sharp concrete edges on the deck surface which could puncture the membrane shall be corrected in a manner satisfactory to the Engineer prior to application of the primer. Exposed aggregate or rough spots shall be smoothed.

A 1/2 to 3/4 in. (13 to 20 mm) fillet of grout shall be placed in the cove area between curb, parapet, median and expansion dam faces, and the deck surface to prevent a void area where the membrane turns up the vertical face. The grout mixture shall be one part cement and two parts sand mixed with water.

Concrete surfaces, structural steel, railing, passing vehicles, etc. shall be protected to prevent their being defaced by primer or other materials being used. Should defacement occur, the Contractor shall clean surfaces on the structure to the satisfaction of the Engineer and be solely responsible and liable for damage to passing vehicles. From the time the bridge deck is cleaned and prepared for the prime coat until the HMA is spread and compacted, the only traffic permitted on the area being treated shall be the necessary men and equipment to perform the work required.

581.05 Weather and Moisture Limitations. Work shall not be done during wet weather conditions, or when the deck and ambient air temperatures are below 45 °F (7 °C). The deck shall be surface-dry at the time of the application of the primer. The membrane shall not be placed until at least 28 days after deck-concrete placement on new structures unless otherwise directed. On existing structures where the normal traffic flow is interrupted by the project work, as much drying time after the curing period shall be allowed as is feasible before membrane placement.

581.06 Application of Membrane System. Pressure distributors used for the application of the tar emulsion shall be self-propelled, equipped with pneumatic tires, and capable of applying 0.08 to 0.10 gal/sq yd (0.4 to 0.5 L/sq m) of tar emulsion over the required width of application. Distributors shall be equipped with removable manhole covers, tachometers, pressure gauges, and volume measuring devices.

Mixing and agitating equipment furnished shall be either a portable power mixer or a tank-type power mixer. A portable mixer for use in drums shall have sufficient power and propeller blades shaped to thoroughly mix and pull the material upward from the bottom of the drum. Mixing in tanks may be done in round bottom tanks equipped with a power driven mixer of sufficient capacity to maintain the emulsion in suspension.

The primer and full membrane shall extend up the curb faces and other vertical barriers to at least the elevation of the top of the surfacing. The lips of drain openings and edges of open joints, deck slab, and other openings at deck level shall be completely sealed by extending the full waterproofing course over the lip or edge.

The penetrating primer shall be applied by spraying, preferably with high pressure hydraulic equipment using hand-held spray bars that permit close control of the quantity applied. Applied at the rate of approximately 0.01 gal/sq yd (0.05 L/sq m), the quantity shall be controlled to produce a "brown coat" filling all pores and depressions but devoid of lakes or pools showing a solid film when dried

out. The purpose of the primer is to neutralize the concrete surface and not to produce a membrane film by itself.

Primer shall not be diluted unless ordered by the Engineer. A distributor truck shall not be used to apply the primer unless its performance has been demonstrated and its use approved by the Engineer. Surfaces shall be dry when primer is applied, and the weather and atmospheric conditions favorable for a drying period of at least four hours. Care shall be taken that the primer does not flow onto nor is applied over bituminous or mastic materials.

Coal tar pitch emulsion shall not be applied until the primer has cured according to manufacturer's recommended dry time or until all solvents that may cause bleeding of the emulsion have evaporated. The coal tar pitch emulsion coatings shall not be applied when the weather is foggy or when rain threatens, or when the atmospheric or pavement temperature is below 45 °F (7 °C).

Due to the settling that may take place in transit, the emulsion shall be thoroughly agitated by power mixers so that a homogeneous consistency is assured for proper and uniform application.

A total of four applications of emulsion shall be applied to the deck, the fourth coat being in the form of a slurry. The slurry shall be applied at the rate of 0.30 gal/sq yd (1.4 L/sq m) in order to obtain 0.13 to 0.15 gal (0.5 to 0.6 L) of undiluted coal tar emulsion per square yard (square meter). The first three coats of undiluted coal tar emulsion shall be applied at the rate of 0.08 to 0.10 gal/sq yd (0.4 to 0.5 L/sq m). Two layers of fiberglass fabric shall be placed parallel to the length of the bridge. The necessary time shall be allowed between coats for proper setting. After the roadway surface has been properly primed and approved by the Engineer, the coal tar pitch emulsion shall be applied according to one of the two following methods.

- (a) Hand Method. The emulsion shall be applied in four coats in the amounts per square yard (square meter) as required. The undiluted material shall be poured in strips on the pavement and spread with a squeegee or brush, smoothing out with a brush. This procedure shall be continued until the entire area is covered. Application can also be made by means of a heavy spray gun when approved by the Engineer. The first coat shall be allowed to dry or cure sufficiently to prevent pickup before the second coat is applied. When spreading the second coat, it shall be spread crosswise to the placing of the first coat when practicable.
- (b) Distributor or Applicator. When applied by distributor or approved type of applicator, the emulsion shall be applied uniformly to the surface of the pavement at the prescribed pressures and in the amount per square yard (square meter) as stated. The emulsion shall be thoroughly mixed before use. When necessary to dilute the emulsion in order to aid proper application, the emulsion may be diluted with a maximum of ten percent by volume of clean fresh water as directed by the Engineer.

In all cases, the waterproofing shall begin at the low point of the surface to be waterproofed so that water will run over and not against the laps.

One width of the fiberglass fabric shall be laid loosely into the second coat of emulsion while the film is still wet. The fabric shall be brushed into the emulsion thereby eliminating all wrinkles and blisters, but without stretching the fabric tight. The adjoining widths of fabric shall be installed in the same fashion, side lapping the former by 3 in. (75 mm). All end laps shall be at least 12 in. (300 mm). The upper layer of fabric shall be applied in the same manner, but the laps shall extend over the lower laps by at least 6 in. (150 mm).

The fourth coat shall be a slurry top coat. The emulsion and aggregate shall be blended and premixed to produce a slurry top coat. The coal tar emulsion may be diluted up to a ratio by volume of 0.1 parts water to one part coal tar pitch, emulsion to facilitate the mixing and spreading of the slurry. The slurry shall contain a nominal 4 lb (0.5 kg) of fine aggregate per gallon (liter) of coal tar pitch emulsion.

Before application, the materials shall be proportioned accurately and mixed by suitable mixing equipment. Mixing machines for preparing the slurry may be mortar mixers, concrete mixers, or any type approved by the Engineer capable of producing a uniform mixture of emulsion and aggregate. The emulsion and the water shall be first charged into the mixer and blended into the desired consistency. Then the aggregate shall be added at a slow and uniform rate while the mixing is continued until the batch aggregate is incorporated. After all the components are in the mixer, the mixing shall continue for minimum of five minutes or as long as may be necessary to produce a smooth, free flowing, homogeneous mixture of a uniform consistency. Mixing shall be continuous from the time the bitumen is placed into the mixer until the slurry is poured into the spreading equipment.

During the entire mixing process, there shall be no breaking, segregating or hardening of the emulsion, nor balling, lumping, or swelling of the aggregate. After the required mixing period, the slurry shall be spread over the designated area while the slurry is of the proper consistency. The slurry shall be applied at the rate of 0.28 to 0.30 gal/sq yd (1.3 to 1.4 L/sq m) in order to obtain 0.13 to 0.15 gal (0.5 to 0.6 L) of undiluted coal tar emulsion per square yard (square meter).

The application of the slurry shall be either by hand methods using rubber squeegees for spreading or by any other suitable mechanical method approved by the Engineer. The slurry shall be applied at a uniform rate as specified.

A suitable spray type applicator or distributor approved by the Engineer may be used for applying the slurry. Such equipment shall be equipped with an agitator to keep the slurry uniformly mixed before and during application and so designed to uniformly spread the slurry on the roadway at the specified rate of application.

At all times, particular care shall be taken to protect the membrane from damage. Any damage which may occur shall be repaired by patching in a manner satisfactory to the Engineer. The complete membrane shall be allowed to cure for at least 24 hours before placement of the protection layer.

581.07 Protection Layer. The fine aggregate and asphalt binder shall be combined in such proportions that the composition by weight of the finished mixture shall be as directed by the Engineer but within the following range limits.

Fine Aggregate	90.0 to 93.0 %
Asphalt Binder	7.0 to 10.0 %

The hot-mix asphalt (HMA) plant used for the manufacture of the protection course material shall be capable of producing completely coated uniform mixtures within the tolerances set forth and at a uniform workable temperature as specified by the Engineer, but not to exceed 350 °F (175 °C) for the mixture when leaving the plant.

The exact proportions, within the limits specified, shall be regulated so as to produce a satisfactory mixture with all particles coated with asphalt binder. The fine aggregate shall be mixed dry for not less than 15 seconds. The asphalt binder shall then be added in an evenly spread sheet over the full length of the mixer box. The mixing shall be continued for a period of not less than 30 seconds and at least until the aggregate is completely coated with asphalt binder.

The asphalt sand seal protection layer shall be placed and compacted according to the requirements of Section 406, except that the material shall not be mixed or placed when the atmospheric temperature is below 50 °F (10 °C). The temperature of the mix shall not be less than 290 °F (144 °C) at time of placement. The mix shall be placed and compacted so as to provide a protection layer of approximately 1/2 in. (13 mm) in thickness.

581.08 Sequence of Construction Operations. The sequence of construction operations for the waterproofing membrane systems shall be as follows.

- (a) Penetrating Primer 0.01 gal/sq yd (0.05 L/sq m) [manufacturer's recommended cure time]
- (b) Coal Tar Emulsion 0.08 to 0.10 gal/sq yd (0.4 to 0.5 L/sq m) [Cure 4 Hrs.]
- (c) Coal Tar Emulsion 0.08 to 0.10 gal/sq yd (0.4 to 0.5 L/sq m) & Fiberglass Fabric 1.65 oz/sq yd (55 g/sq m) [Cure 4 Hrs.]
- (d) Coal Tar Emulsion 0.08 to 0.10 gal/sq yd (0.4 to 0.5 L/sq m) & Fiberglass Fabric 1.65 oz/sq yd (55 g/sq m) [Cure 4 Hrs.]
- (e) Coal Tar Emulsion Slurry 0.3 gal/sq yd (1.4 L/sq m) [Cure 24 Hrs.]
- (f) Asphalt Sand Seal Protection Layer 1/2 in. (13 mm) thick

581.09 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).

- (b) **Measured Quantities.** This work will be measured for payment and the area computed in square yards (square meters) of bridge deck surface covered. No measurement or allowance will be made for laps, material used for extending up curb faces or other vertical barriers, material used for extensions over lips or edges, or for repairs.

581.10 Basis of Payment. This work will be paid for at the contract unit price per square yard (square meter) for WATERPROOFING MEMBRANE SYSTEM.

SECTION 582. HOT-MIX ASPHALT SURFACING ON BRIDGE DECKS

582.01 Description. This work shall consist of constructing a hot-mix asphalt (HMA) surface course on a prepared bridge deck.

582.02 Materials. Materials shall be according to Article 406.02.

582.03 Equipment. Equipment shall be according to Article 406.03, except vibratory rollers will not be permitted on bridge decks.

CONSTRUCTION REQUIREMENTS

582.04 General. Work shall be according to Section 406, except as specified herein.

Only a tandem roller, meeting the requirements of Table 1 of Article 406.07(a), will be permitted for breakdown rolling.

582.05 Target Density. A target density will be established from tests conducted on a calibration strip consisting of 100 ft (30 m) of HMA surface course placed on the bridge deck.

A target count rate which represents the maximum compactive effort will be determined with nuclear testing equipment within the calibration strip.

Compaction of the calibration strip with the breakdown roller shall commence immediately after the surface course is placed and shall be continuous and uniform over the entire area. All rolling operations must be completed before the temperature of the mixture drops below 190 °F (90 °C). At a minimum of two random locations within the calibration strip, a growth curve consisting of a plot of counts per minute vs. number of passes with a breakdown roller will be developed.

The growth curve at each random location will be established by using a nuclear gauge using a fast count or with a nuclear gauge using a 30-second timing cycle in the backscatter position. Tests will be made after each pass until the lowest count either raises or remains the same. At this time, mineral filler will be spread and a 4 minute (calibration) count will be taken in the backscatter position to establish the relative target density.

The established average target density shall apply throughout the project unless there are changes in mix materials or an appreciable change in the job mix formula. The Engineer may require a new average target density to be established if there is reason to believe that the mixture being placed is not the same as the mixture used to determine the target density.

582.06 Acceptance Tests. Acceptance tests will be performed once the average target density has been established. At least one acceptance test will be taken for each 200 ft (60 m) or portion thereof of bridge deck per paver pass. Acceptance tests on material placed in a single day shall average 98 percent of the established average target density with no one test being below 95 nor more than 103 percent of the established target density. If the above requirements for average or individual density tests cannot be obtained, placement of additional material will be discontinued until the cause of the failure is investigated and corrected.

Acceptance tests will be performed with the same nuclear equipment used to establish the average target density. Acceptance tests will be for one-minute duration and the area to be tested shall be prepared with mineral filler prior to testing.

582.07 Method of Measurement. This work will be measured for payment according to Article 406.13.

582.08 Basis of Payment. This work will be paid for according to Article 406.14.

SECTION 583. PORTLAND CEMENT MORTAR FAIRING COURSE

583.01 Description. This work shall consist of placing portland cement mortar along precast, prestressed concrete bridge deck beams as required for fairing out any unevenness between adjacent deck beams prior to placing of waterproofing membrane and surfacing.

583.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement	1001.01(a)
(b) Fine Aggregate	1003.02
(c) Water	1002

CONSTRUCTION REQUIREMENTS

583.03 General. This work shall only be performed when the air temperature is 45 °F (7 °C) and rising. The mixture for portland cement mortar shall consist of three parts sand to one part portland cement by volume. The amount of water shall be no more than that necessary to produce a workable, plastic mortar.

Prior to placement of the mortar fairing course, all areas where unevenness occurs between the deck beams shall be prepared according to Article 503.09(b).

The mortar shall be placed to the thickness necessary to eliminate unevenness between the beams. It shall be placed to form a smooth even surface from the higher beam edges to the lower surface. The mortar finished surface shall slope not less than 1:3 (V:H) and shall be feathered smoothly into the deck beam surfaces. The finish shall be free of depressions or sharp edges.

The mortar shall be cured for a period of not less than three days by the wetted burlap method according to Article 1020.13(a)(3). Curing shall commence as soon as practicable after mortar placement.

583.04 Method of Measurement. This work will be measured for payment in feet (meters) along the beam edges.

583.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for PORTLAND CEMENT MORTAR FAIRING COURSE.

SECTION 584. GROUTING OF ANCHOR RODS AND BARS

584.01 Description. This work shall consist of drilling and grouting anchor rods and bars into hardened concrete.

584.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Chemical Adhesive Resin System	1027

CONSTRUCTION REQUIREMENTS

584.03 General. Holes shall be drilled in the concrete to 1/4 in. (6 mm) larger in diameter than the diameter of the anchor rods or bars and to the depth shown on the plans. A template or other approved method shall be used to assure accurate location of the drilled holes. All holes shall be blown free of concrete dust and chips and shall be absolutely dry prior to placing the chemical adhesive.

Prior to inserting the anchor rod or bar into the hole, the hole shall be filled approximately 1/3 full of the mixed chemical adhesive. The anchor rod or bar shall be inserted into the partially filled hole and moved up and down several times to insure total contact of the chemical adhesive with concrete as well as the rod or bar. Additional chemical adhesive shall be extruded to proper concrete level and finished as necessary. The anchor rod or bar shall be aligned to maintain a perpendicular plane. No load shall be applied to the anchors until the chemical adhesive has cured for at least 24 hours.

584.04 Basis of Payment. This work will not be measured or paid for separately, but shall be considered as included in the unit price bid for the item of construction involved.

SECTION 585. RESERVED

SECTION 586. SAND BACKFILL FOR VAULTED ABUTMENTS

586.01 Description. This work shall consist of furnishing, transporting and placing sand backfill behind vaulted abutments to serve as a form for the placement of the concrete approach slab.

586.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Fine Aggregate (Note 1)	1003.01

Note 1. The material for backfilling shall be bank-run or stockpiled sand.

CONSTRUCTION REQUIREMENTS

586.03 General. The wedge behind the abutments shall be backfilled with the sand material to the required elevation of the bottom of the approach span slabs. The backfill shall be placed in convenient lifts for the full width between the abutment sidewall. Mechanical compaction will not be required. Backfilling shall not be started until test specimens show that the concrete in the abutment has attained a flexural strength of 650 psi (4,500 kPa) but in no case until at least seven days have elapsed after the placing of the concrete. In the absence of tests to determine the flexural strength, the sand backfill shall not be placed until at least 14 days have elapsed after the placing of the concrete, exclusive of days on which the temperature of the air surrounding the concrete falls below 45 °F (7 °C).

The sand backfill shall be brought to the finished grade of the bottom of the abutment approach slab to serve as a base for placement of the slab. The Contractor, subject to approval of the Engineer, may prepare the top surface of the fill to receive the concrete as he/she deems necessary for satisfactory placement at no additional cost to the Department.

586.04 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. This work will be measured for payment in place and the volume computed in cubic yards (cubic meters). The volume will be determined by measuring the wedge areas above the embankment slope, behind the abutment mainwalls, and for the full width between sidewalls.

586.05 Basis of Payment. This work will be paid for at the contract unit price per cubic yard (cubic meter) for SAND BACKFILL.

SECTION 587. CONCRETE SEALER

587.01 Description. This work shall consist of furnishing and applying a sealer to concrete structures as shown on the plans.

587.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Concrete Sealer	1026

CONSTRUCTION REQUIREMENTS

587.03 General. Before the sealer is applied, the concrete surface shall have a minimum 48 hour drying period, and shall be cleaned with oil-free compressed air or wire brushes to remove all oil, grime, and loose particles. Surfaces that will not respond to cleaning by compressed air or wire brushes shall be cleaned by sandblasting.

Care shall be taken to prevent the sealer from flowing over the edges and onto any concrete that is not to be sealed.

The sealer shall be applied according to the manufacturer's instructions, and information provided in the approved list of Concrete Sealers.

587.04 Method of Measurement. This work will be measured for payment in place and the area computed in square feet (square meters).

587.05 Basis of Payment. This work will be paid for at the contract unit price per square foot (square meter) for CONCRETE SEALER.

SECTION 588. RESERVED

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SECTION 589. ELASTIC JOINT SEALER

589.01 Description. This work shall consist of furnishing and placing an elastic sealer in joints of hot-mix asphalt (HMA) surface course on bridge decks.

589.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Hot-Poured Joint Sealer	1050.02

CONSTRUCTION REQUIREMENTS

589.03 General. Prior to sealing, the joint shall be sawed to form a reservoir for the sealing material. The sawed joint shall be 1/4 in. (6 mm) wide and 3/4 in. (20 mm) deep. Immediately prior to pouring the elastic sealer, the joint shall be cleaned with compressed air and shall be free of foreign and loose material and in a dry condition. The joint shall not be poured when the temperature is below 40 °F (4 °C) or when the weather is foggy or rainy.

The equipment required for this work shall be approved by the Engineer before the work will be permitted to start. The heating apparatus and equipment for applying the sealing material shall meet the recommendations of the manufacturer supplying the sealing material, and shall be such that the joint will be completely filled from bottom to top to the satisfaction of the Engineer.

Sufficient compound shall be placed in the joints so that the top of the seal is flush with the top surface of the wearing course.

589.04 Basis of Payment. This work will not be paid for as a separate item, but shall be considered as included in the unit price bid for the item of HMA surface course involved.

SECTION 590. EPOXY CRACK INJECTION

590.01 Description. This work shall consist of injecting cracks in structural concrete with an epoxy bonding compound, or as designated in the contract.

590.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Epoxy Bonding Compound	1025.01

CONSTRUCTION REQUIREMENTS

590.03 General. Only cracks or portions thereof that are 0.007 in. (0.2 mm) or wider shall be injected.

The areas for epoxy crack injection shall be prepared by removing all dust, debris, or disintegrated material from the crack by the use of oil-free compressed air and/or vacuuming. Any cracks holding oil or grease shall be chipped out to clean concrete.

Horizontal and vertical cracks shall have suitable one-way injection ports installed every 6 to 18 in. (150 to 450 mm) or as required, depending on the width of crack, the horizontal or vertical location, and the dimensions of the member. The surface of cracks between the injection ports shall be sealed with a suitable sealing compound recommended by the supplier of the epoxy bonding compound. When the sealing compound is cured, mechanical pressure equipment shall be used to inject the epoxy bonding compound into the cracks.

Injection shall begin at the bottom and progress upward when applicable. The injection pressure and epoxy bonding compound flow characteristic shall result in 90 percent penetration of the epoxy bonding compound. Injection shall continue until refusal, and without damage to the structural concrete. Pressure injection shall not exceed 500 psi (3450 kPa). When the epoxy bonding compound is cured, the injection ports and sealing compound shall be removed and the surface smoothed by stoning or grinding.

590.04 Method of Measurement. This work will be measured for payment in place in feet (meters).

590.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for EPOXY CRACK INJECTION.

SECTION 591. GEOCOMPOSITE WALL DRAIN

591.01 Description. This work shall consist of furnishing and installing geocomposite wall drain on the soil side of abutment walls, wing walls, retaining walls, and culvert sidewalls.

591.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Geocomposite Wall Drain	1040.07

CONSTRUCTION REQUIREMENTS

591.03 General. Geocomposite wall drain shall be constructed in horizontal courses with the first course resting on the top of the footing. The geocomposite shall be in direct contact with the wall and secured with concrete nails not less than 2 in. (50 mm) long with approved washers not less than 9 sq in. (5800 sq mm) in area. The spacing of the concrete nails shall be as directed by the Engineer but shall not be more than 3 ft (1 m) apart, both horizontally and vertically. There shall be at least one horizontal row of nails in each course.

Horizontal seams shall be formed by a 4 in. (100 mm) flap of geotextile extending from the upper course and lapping over the top of the lower course or by a 12 in.

(300 mm) wide continuous strip of geotextile centered over the seam and securely fastened to the upper course with continuous 3 in. (75 mm) wide plastic tape. The overlapping flap or strip shall be fastened to the lower course intermittently as directed by the Engineer, but the spacing shall not exceed 2 ft (600 mm). Vertical splices shall be formed by a 4 in. (100 mm) flap of geotextile extending from one or the other abutting pieces or by a 12 in. (300 mm) wide continuous strip of geotextile centered over the splice. Vertical splice flaps or strips shall be continuously fastened to the geocomposite with continuous applications of contact adhesive or 3 in. (75 mm) wide plastic tape.

The bottom, side, and top edges of the geocomposite shall be covered with a suitable cap formed by folding a 6 in. (150 mm) flap or a 12 in. (300 mm) wide strip of geotextile over the edge and securing it in place with a continuous application of contact adhesive or 3 in. (75 mm) wide plastic tape. All seams, splices, bottom caps, top caps, and end caps shall be constructed so that backfill material cannot enter the geocomposite during or after construction.

Connection to pipe outlet systems shall be as shown on the plans. Outlet fittings shall be fastened to the wall drains as directed by the manufacturer and so that backfill materials cannot enter the system during or after construction. If necessary, to facilitate the rapid and complete flow of water from the wall drain into the pipe outlet, a portion of the wall drain core equal to the cross section at the outlet shall be removed. Weep holes shall be accommodated by cutting a matching hole through the wall drain. An approved weep hole cover extending at least 4 in. (100 mm) from the edge(s) of the hole shall be securely fastened to the soil side of the wall drain by 3 in. (75 mm) wide plastic tape or contact adhesive applied continuously around its periphery.

591.04 Method of Measurement. This work will be measured for payment in place and the area computed in square yards (square meters).

591.05 Basis of Payment. This work will be paid for at the contract unit price per square yard (square meter) for GEOCOMPOSITE WALL DRAIN.

SECTION 592. BRIDGE WASHING

592.01 Description. This work shall consist of washing the entire bridge, including bridge deck, sidewalk, curbs, pier and abutment caps, all superstructure members, trusses, interior of truss members, flanges and webs of beams or girders, expansion joints, and drains to prevent deterioration of the structure.

592.02 Materials. Water shall be according to Section 1002.

592.03 Equipment. Washing equipment shall consist of power brooms, air compressors, water tanks, water pumps with associated delivery hardware, and hand tools, to properly flush, clean, and remove all foreign material from the bridge structure. Other types of washing equipment may be used, subject to approval of the Engineer. Water pressure shall be sufficient to remove the accumulated material without damaging paint coverage of the structural steel.

Other equipment may be necessary to gain access to areas designated for washing. It will be the Contractor's responsibility to determine and utilize whatever method and equipment best suits his/her operation to successfully wash the structure. This equipment shall be available to the inspector until final acceptance of the work.

CONSTRUCTION REQUIREMENTS

592.04 General. All accumulated foreign material shall be removed from the bridge. Special care shall be taken on connected parts, members below open joints and difficult to reach areas to remove all foreign material.

All deck drains shall be flushed with water under pressure. Blockages in the deck drains shall be removed so that they will drain properly. The drain system may have to be taken apart to remove large blockages. Should they be taken apart, they shall be returned to their original configuration immediately after washing. Foreign material in the scuppers at the drains shall be either removed externally or flushed down the drain system. The area beneath all expansion devices shall be thoroughly flushed and washed with water under pressure. These areas include drain troughs beneath the expansion device and pier tops immediately adjacent to the expansion device. All abutment and bridge seats shall have foreign material removed by compressed air, water under pressure, or hand sweeping. All structural steel and bearings shall be washed with water under pressure. All foreign debris shall be removed from truss members. All foreign material accumulated in the interior of members shall be removed. Areas which have been washed shall be free of all accumulate sand, gravel, dirt, bird nests and excrete, and other foreign materials. Free standing water shall be removed upon completion of washing.

The Contractor shall provide adequate protection against worker inhalation of dust from his/her washing operations.

The Contractor shall exercise due caution while washing those portions of the structures that are adjacent to or above parking lots, buildings, sidewalks, roadways, and railroad tracks. Dirt and debris deposited on adjacent property or redeposited on the bridge shall be removed to the satisfaction of the Engineer.

The Contractor shall obtain his/her own source of water.

592.05 Traffic Control. The road shall be kept open to traffic according to Article 701.17(d)(4).

592.06 Method of Measurement. This work will be measured for payment in units of each, at the locations specified.

592.07 Basis of Payment. This work will be paid for at the contract unit price per each for BRIDGE WASHING at the location specified.

SECTION 593. CONTROLLED LOW-STRENGTH MATERIAL, BACKFILL

593.01 Description. This work shall consist of furnishing and placing controlled low-strength material (CLSM) as backfill for pipe culverts, storm sewers, structure excavation, or other excavations as specified.

593.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Controlled Low-Strength Material (CLSM)	1019

CONSTRUCTION REQUIREMENTS

593.03 General. The mix shall not be placed on frozen ground, in standing water, or during wet weather conditions. Mixing and placing shall begin only when the air temperature is at least 35 °F (2 °C) and rising. At the time of placement, the material temperature shall be at least 40 °F (5 °C). Mixing and placing shall stop when the air temperature is 40 °F (5 °C) and falling.

The mix shall not be exposed to freezing temperatures or wet weather conditions during the first 24 hours after placement.

The mix may be subjected to loading upon approval by the Engineer or when a penetration of 1.5 in./blow (38 mm/blow) or less has been obtained with the Dynamic Cone Penetration (DCP) test.

593.04 Placement. The mix shall be placed directly from the chute into the space to be filled. Other placement methods may be approved by the Engineer if the mix design is appropriate.

- (a) Structures. When backfilling against structures, the mix shall be placed in lifts to prevent damage by lateral pressures. Side slopes shall be stepped or serrated to prevent wedging action of the backfill against the structure. Each lift shall be allowed to harden prior to placing the next lift.
- (b) Pipes. When backfilling pipe culverts or storm sewers, the mix shall be distributed evenly on each side of the pipe and placed in lifts. The first lift shall be placed up to one-fourth the height of the pipe and allowed to settle. After settlement of the first lift, as determined by the Engineer, the second lift shall be placed up to one-half the height of the pipe and allowed to settle. After settlement of the second lift, as determined by the Engineer, the remainder of the trench shall be filled.

When backfilling concrete pipes, the mix may be placed in a single lift.

593.05 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of contract quantities shall be according to Article 202.07(a).

- (b) **Measured Quantities.** This work, when specified, will be measured for payment in place and the volume computed in cubic yards (cubic meters).
- (1) **Structures.** When CLSM is specified for backfilling structures, the computed volume will not exceed the volume computed for the excavation according to Article 502.12(b) with a deduction for the volume of the structure.
- (2) **Pipe Culverts and Storm Sewers.** When CLSM is specified for backfilling pipe culverts or storm sewers, the computed volume will not exceed the volume of the trench as computed by using the trench width specified in Sections 542 and 550 and the actual depth of the completed backfill above the top of the bedding materials, with a deduction for the volume of the pipe.

593.06 Basis of Payment. This work will be paid for at the contract unit price per cubic yard (cubic meter) for CONTROLLED LOW-STRENGTH MATERIAL.

DIVISION 600. INCIDENTAL CONSTRUCTION

DRAINAGE RELATED ITEMS

SECTION 601. PIPE DRAINS, UNDERDRAINS, AND FRENCH DRAINS

601.01 Description. This work shall consist of constructing pipe drains and pipe underdrains of the required inside diameter, and constructing french drains consisting of trenches filled with aggregate.

Pipe underdrains in backslopes shall be designated as follows.

Depth of Installation	Type
4 ft (1.2 m) or less	Backslope Drains, Type 1
Greater than 4 ft (1.2 m) not exceeding 8 ft (2.4 m)	Backslope Drains, Type 2
Greater than 8 ft (2.4 m) not exceeding 12 ft (3.6 m)	Backslope Drains, Type 3

601.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) *Corrugated Steel Pipe (Note 1)	1006.01
(b) *Bituminous Coated Corrugated Steel Pipe (Note 1)	1006.01
(c) Perforated Corrugated Steel Pipe (Note 1) (Note 5)	1006.01
(d) *Corrugated Aluminum Alloy Pipe (Note 1)	1006.03
(e) *Bituminous Coated Corrugated Aluminum Alloy Pipe (Note 1)	1006.03
(f) Perforated Corrugated Aluminum Alloy Pipe (Note 1) (Note 5)	1006.03
(g) Drain Tile	1040.01
(h) Extra Strength Clay Pipe (Note 4)	1040.02
(i) Extra Strength Perforated Clay Pipe (Note 5)	1040.02
(j) *Concrete Sewer, Storm Drain, and Culvert Pipe, Class 3	1042
(k) Concrete Drain Tile	1042
(l) *Polyvinyl Chloride (PVC) Pipe	1040.03
(m) Perforated Polyvinyl Chloride (PVC) Pipe (Note 5)	1040.03
(n) Perforated Corrugated Polyvinyl Chloride (PVC) Pipe with a Smooth Interior (Note 5)	1040.03
(o) *Corrugated Polyvinyl Chloride (PVC) Pipe with a Smooth Interior (Note 4)	1040.03
(p) *Corrugated Polyethylene (PE) Pipe (Note 2)	1040.04
(q) Perforated Corrugated Polyethylene (PE) Pipe (Note 2) (Note 5)	1040.04
(r) Perforated Corrugated Polyethylene (PE) Pipe with a Smooth Interior (Note 5)	1040.04
(s) *Corrugated Polyethylene (PE) Pipe with a Smooth Interior (Note 4)	1040.04
(t) Drainage Mat Underdrain (Note 3)	1040.06
(u) Sand Backfill for Underdrains and Bedding	1003.04
(v) Aggregate for French Drains	1003.04, 1004.05
(w) Geotechnical Fabric for French Drains	1080.05
(x) Grout	1024.01

*Pipe drains are limited to this type material and this material will not be permitted for pipe underdrains.

Note 1. The thickness for steel and aluminum pipe shall be as shown in tables 1B and 1C of Article 542.03 for pipe having up to 3 ft (900 mm) of cover over the top of the pipe. The thickness for corrugated steel pipe shall be 0.052 in. (1.32 mm) for a pipe with a nominal diameter of 6 in. (150 mm) and 0.064 in. (1.63 mm) for a pipe with a nominal diameter of 8 in. (200 mm). Corrugations of 1 1/2 x 1/4 in. (38 x 6.5 mm) shall be used in lieu of 2 2/3 x 1/2 in. (68 x 13 mm) corrugations for 6 in. (150 mm) and 8 in. (200 mm) diameter pipes. The thickness for corrugated aluminum alloy pipe shall be 0.048 in. (1.22 mm) for a pipe with a nominal diameter of 6 in. (150 mm) and 0.060 in. (1.52 mm) for a pipe with a nominal diameter of 8 in. (200 mm).

Note 2. This material is limited to 4 in. (100 mm) diameter.

Note 3. This material will be permitted when pipe underdrains 4 in. (100 mm) is specified.

Note 4. This material shall be used for pipe underdrains (special).

Note 5. This material shall be encased in a fabric envelope for pipe underdrains.

No open joint pipe will be allowed for pipe underdrains used under or along the edge of pavement or shoulders and for pipe drain outlets.

The Contractor may be permitted to substitute a stronger tile or pipe of the same kind of material for any tile or pipe as listed above. No extra compensation will be allowed for such substitution.

When metric pipe sizes are specified, the next larger manufactured size of English pipe may be substituted at no additional cost to the Department.

CONSTRUCTION REQUIREMENTS

601.03 Pipe Drain Installation. Pipe drains shall be installed at the locations shown on the plans. The pipe shall be bedded in the underlying material to a depth not less than ten percent of the external diameter of the pipe and, where trenching is required, the trench shall have a width of not less than the external diameter of the pipe plus 18 in. (450 mm). The bottom of the trench shall be compacted in a manner meeting the approval of the Engineer.

Joints and fittings may be assembled without gaskets or solvent cement if the joint is hand tight and the spigot enters the socket not less than 1/3 of the socket depth for solvent cement joints and full-depth for elastomeric gasket joints.

The trench and prepared foundation shall be approved by the Engineer prior to placement of the pipe. The pipe shall be laid so that the flow line will be at the grade shown on the plans or established by the Engineer. The permissible minimum cover over a pipe shall be 6 in. (150 mm).

Laying of pipes shall commence at the outlet end and proceed toward the inlet end with the pipes true to line and grade.

The ends of the pipe shall be carefully cleaned before they are placed, and shall be placed to avoid unnecessary handling on the foundation. As each length of pipe is laid, the ends of the pipe shall be protected to prevent the entrance of any material.

Longitudinal laps shall be placed at the sides and separate sections of pipe shall be joined with tightly drawn, approved connecting bands.

The trench shall be backfilled with select material, meeting the approval of the Engineer, placed in 8 in. (200 mm) layers, loose measurement, and compacted to the Engineer's satisfaction.

Material excavated from the trench, if it meets the approval of the Engineer, may be used for backfill.

Unsuitable material and suitable material in excess of that required for backfilling shall be disposed of by the Contractor according to Article 202.03.

601.04 Pipe Underdrain Installation. Pipe underdrains placed along pavement edges shall be outletted across the shoulder to the ditch approximately every 500 ft (150 m) and at all low points in the flow line of the underdrain. Pipe underdrains may be outletted into the cross road culvert when the fill above the culvert is 5 ft (1.5 m) or less. Pipe underdrains shall be outletted using pipe underdrain (special) according to the details shown on the plans.

When pipe underdrains are included in contracts involving pavement patching, the pipe underdrains shall be installed after patching operations.

When installing pipe underdrains on contracts with existing shoulders and it is determined by the Engineer that the Contractor's equipment or method of excavation is causing the material under the pavement to become dislodged, the Contractor shall move the location of the trench laterally away from the pavement a sufficient distance so that edge sluffing will not occur under the pavement. No additional compensation will be allowed the Contractor for any increases in cost or quantities of backfill material that may be caused by a change in the location of the pipe underdrain trench.

On contracts where existing shoulders are to be resurfaced, the trench of the pipe underdrain and pipe underdrain (special) shall be backfilled with FA 1 or FA 2 to within 5 in. (125 mm) of the surface of the existing shoulder. The top 5 in. (125 mm) of the trench shall be backfilled with an "All Other" mixture meeting the requirements of Section 1030 and compacted to a density of not less than 90 percent of the theoretical density.

On contracts where the existing shoulders are not being resurfaced, the trench of the pipe underdrain and pipe underdrain (special) shall be backfilled with FA 1 or FA 2 to within 8 in. (200 mm) of the surface of the existing shoulder. The top 8 in. (200 mm) of the trench shall be backfilled with an "All Other" mixture according to

Section 1030 and compacted to a density of not less than 90 percent of the theoretical density.

Perforated pipe shall be placed with the perforations down and the pipe sections shall be joined securely with the appropriate coupling fittings or bands.

Non-perforated pipe with bell ends shall be laid with the bell end up and with open joints wrapped with suitable material to permit entry of water or unwrapped as specified. Upgrade ends of all pipe installations shall be closed with suitable plugs to prevent entry of soil materials.

No equipment shall be operated directly upon the completed pipe installation for longitudinal underdrains constructed along the edges of pavement or subbase.

Unsuitable material and suitable material in excess of that required for backfilling shall be disposed of by the Contractor according to Article 202.03.

- (a) Perforated Corrugated Polyethylene (PE) Tubing. Trenches shall be excavated to the dimensions and grades required by the plans. In no case, shall the diameter of the 180 degree semicircular bedding groove exceed the outside diameter of the plastic tubing and fabric envelope by more than 1/4 in. (6 mm) and in no case, shall the width of trench exceed 10 in. (250 mm). The trench bottom outside the limits of the bedding groove shall be undisturbed and free of loose material.

The excavation of the trench and 180 degree semicircular bedding groove and the placement of the underdrain tubing shall be accomplished in a single continuous operation. The underdrain tubing shall be laid true to grade and shall not be stretched more than five percent during installation. The underdrain tubing shall be seated in the bedding groove and held firmly in place by mechanical means while sand backfill is placed and compacted to a height of 5 in. \pm 1 in. (125 mm \pm 25 mm) above the tubing. After the first lift is compacted, the remainder of the sand backfill shall be placed and compacted. Placement and compaction of the remainder of the backfill may be included in the same pass as the excavation of the trench and bedding groove and the placement of the tubing. When approved by the Engineer, placement and compaction of the two lifts of backfill may be accomplished in a separate operation closely following the trenching and tubing placement. The maximum distance between the two operations shall be the greater of 500 ft (150 m) or the distance trenched in 15 minutes. The distance shall be further limited as necessary to assure the tubing remains firmly seated in the bedding groove with no loose material from the trenching or other operation under or alongside the tubing. Sloughing of the trench wall shall be prevented. The minimum density of the compacted backfill shall be 90 percent of the standard laboratory density determined according to AASHTO T 99 (Method A).

- (b) Drainage Mat Underdrain. When drainage mat underdrain is being installed in lieu of 4 in. (100 mm) diameter underdrain, the trench shall be excavated to the dimensions and grade required by the plans.

Drainage mat underdrain shall be placed against the shoulder side of the trench without damaging the core or tearing the fabric and held firmly in place while FA 1 or FA 2 is placed and compacted to a height of 6 in. \pm 1 in. (150 mm \pm 25 mm). After the first lift is compacted by a vibratory wheel or plate compactor with a rated impact force of approximately 5000 lb (22 kN), the remainder of the backfill shall be placed and compacted by a vibratory compactor to the satisfaction of the Engineer.

Each length of drainage mat underdrain shall be joined to the adjacent length prior to installation. Splices shall keep the adjoining mats in proper alignment, not separate during installation, have the same or better compressive strength than the mat and be sealed against infiltration of backfill material.

- (c) **Pipe Underdrains Other Than PE Tubing and Drainage Mat.** When the pipe for the underdrain is other than corrugated polyethylene (PE) tubing or drainage mat underdrain, the trenches shall be excavated to the dimensions and grade shown on the plans, and a 1 in. (25 mm) layer of bedding material shall be placed and compacted in the bottom of the trench extending upward under the haunches to 1/2 the depth of the pipe underdrain for the full width and length of trench.

The pipe being used for the pipe underdrain shall be embedded firmly in the bedding material.

After the pipe installation has been inspected and approved, granular backfill shall be placed and compacted to a height of 12 in. (300 mm) above the top of pipe. Displacement of the pipe or the covering at open joints shall be prevented. The remainder of the granular backfill material shall then be placed and compacted to the required height. Any remaining portion of the trench above the granular backfill shall be filled with granular or impervious material as specified and thoroughly compacted.

- (d) **Pipe Underdrains (Special).** Pipe underdrain (special) used for outletting pipe underdrains shall be according to the trench requirements for pipe underdrains.

The portion of the pipe underdrain (special) under the paved shoulder shall be backfilled with sand as specified for pipe underdrains. The remaining portion shall be backfilled with select material meeting the approval of the Engineer.

601.05 Concrete Headwalls. Concrete headwalls for pipe drains, pipe underdrains (special) and backslope drains shall be constructed at the locations and according to the details shown on the plans. The headwalls shall be either cast-in-place of Class SI concrete according to the applicable portions of Section 503, or shall be precast. If a precast unit is used, the pipe shall be grouted and sealed to the headwall opening. The grout mixture shall be one part cement and two parts sand mixed with water.

The headwalls shall be placed so that there is a six percent minimum slope on the invert. The uppermost point of the headwall shall be placed flush with the

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roadway slope. The earth side slopes adjacent to the headwall shall then be shaped to conform to the sides and toe of the headwall.

The outlet end of the pipe shall be protected by a permanent rodent shield, upon placement of the pipe drain, pipe underdrain (special) or backslope drain.

The rodent shield shall have the configuration shown on the plans and shall be constructed of hot dip galvanized steel industrial wire cloth. The cloth size shall be 5 x 7 in. (125 x 175 mm) minimum before fabrication of shield for 4 in. (100 mm) pipe. Other submitted designs for a removable rodent shield may be used with the approval of the Engineer.

Unsuitable material and suitable material in excess of that required for backfilling shall be disposed of by the Contractor according to Article 202.03.

601.06 French Drains. French drains shall be constructed at the locations and to the dimensions shown on plans.

The trench shall be excavated to the required width and depth, leveled, and smoothed prior to filling with aggregate. The specified gradation of fine or coarse aggregate shall then be placed to the required depth and covered with the next specified layer of material.

When the use of geotechnical fabric is specified for lining the trench, the fabric shall be delivered to the jobsite in such a manner to facilitate handling and incorporation into the work without damage. In no case shall the fabric be stored and exposed to direct sunlight that might significantly diminish its strength or toughness. Torn or punctured fabric shall not be used.

After the trench has been approved by the Engineer, the fabric shall be loosely rolled out so the center of the fabric is at the centerline of the excavated trench, and it will not tear when the aggregate is placed. When more than one section of fabric is used, the fabric shall overlap a minimum of 2 ft (600 mm). Enough fabric shall remain uncovered after the trench is filled to provide for fabric overlap at the top.

During backfilling with angular aggregates, a minimum 6 in. (150 mm) cushion of the aggregate shall be carefully placed over the lined trench before end dumping larger aggregates out of trucks or other equipment. Following the backfilling operation, the fabric shall be lapped over the top and covered with the next specified material.

Unsuitable material and suitable material in excess of that required for backfilling shall be disposed of by the Contractor according to Article 202.03.

601.07 Method of Measurement. Pipe drains, pipe underdrains, pipe underdrains (special) and backslope drains will be measured for payment in feet (meters), in place. The measured quantities of drainage mat underdrain will be included in the measured quantities of pipe underdrain, 4 in. (100 mm).

Measurement for pipe underdrain (special) will be made from the back of the headwall to the centerline of the longitudinal pipe underdrain. At any location where, due to the type of longitudinal pipe underdrain material being used, more than one

pipe underdrain (special) is required, only one run of pipe underdrain (special) will be measured for payment.

Aggregate used for french drains will be measured for payment in tons (metric tons) or in cubic yards (cubic meters) according to Article 311.08.

Geotechnical fabric for french drains will be measured for payment in place and the area computed in square yards (square meters). The additional fabric required for overlaps of individual sheets and overlaps at the top of the french drain will not be measured for payment.

When pipe underdrains are included on contracts with existing paved shoulders, shoulder removal and replacement over the trench area, as specified in Article 601.04 will be measured for payment in place in feet (meters) along the pipe underdrain and the portion of the pipe underdrain (special) that is under the paved shoulder.

Excavation in rock will be measured for payment according to Article 502.12.

601.08 Basis of Payment. Pipe drains, underdrains, and backslope drains will be paid for at the contract unit price per foot (meter) for PIPE DRAINS; PIPE UNDERDRAINS; PIPE UNDERDRAINS (SPECIAL); BACKSLOPE DRAINS, TYPE 1; BACKSLOPE DRAINS, TYPE 2; or BACKSLOPE DRAINS, TYPE 3; of the diameter specified, or of the kind of material and diameter specified.

Concrete headwalls for pipe drains, pipe underdrains (special) and backslope drains will be paid for at the contract unit price per each for CONCRETE HEADWALLS FOR PIPE DRAINS.

When pipe underdrains are installed through existing paved shoulders, removing and replacing the existing paved shoulder will be paid for at the contract unit price per foot (meter) for SHOULDER REMOVAL AND REPLACEMENT, of the thickness specified.

French drains will be paid for at the contract unit price per ton (metric ton) or cubic yard (cubic meter) for FRENCH DRAINS.

Geotechnical fabric, when required for french drains, will be paid for at the contract unit price per square yard (square meter) for GEOTECHNICAL FABRIC FOR FRENCH DRAINS.

Removal and replacement of unstable or unsuitable material will be paid for according to Article 109.04.

Excavation in rock will be paid for according to Article 502.13.

SECTION 602. CATCH BASIN, MANHOLE, INLET, DRAINAGE STRUCTURE, AND VALVE VAULT CONSTRUCTION, ADJUSTMENT, AND RECONSTRUCTION

602.01 Description. This work shall consist of constructing, adjusting, or reconstructing catch basins, manholes, inlets, or valve vaults, with frames and grates or lids, and constructing drainage structures with frames and grates.

602.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Building Brick (Made from Clay or Shale)	1041.01
(c) Concrete Masonry Units	1042
(d) Gray Iron Castings	1006.14
(e) Precast Reinforced Concrete Catch Basins, Manholes, Inlets, Drainage Structures, and Valve Vaults	1042
(f) Ductile Iron Castings	1006.15
(g) Structural Steel	1006.04
(h) External Sealing Band	1057
(i) Mastic Joint Sealer for Pipe	1055
(j) Preformed Flexible Joint Sealants for Concrete Pipe	1056
(k) Reinforcement Bars and Welded Wire Fabric	1006.10
(l) High Density Polyethylene (HDPE) Plastic Adjusting Rings(Note 2) ..	1043.02
(m) Recycled Rubber Adjusting Rings (Note 3)	1043.03
(n) Fine Aggregate	1003.04
(o) Concrete Brick	1042
(p) Precast Concrete Plug	1042.16(a)

Note: Inlet and outlet tile or pipe shall be of the same size and kind, and shall meet the same requirements as the tile or pipe with which they are connected.

Note 2. HDPE plastic adjusting rings may be used to adjust the frames and grates of drainage and utility structures up to a maximum of 3 in. (75 mm). They shall be installed and sealed underneath the frames according to the manufacturer's specifications.

Note 3. Riser rings fabricated from recycled rubber may be used to adjust the frames and grates of drainage and utility structures up to a maximum of 2 in. (50 mm). They shall be installed and sealed underneath the frames according to the manufacturer's specifications.

602.03 Classification. Classification as to adjustment or reconstruction shall be on the following basis.

- (a) Adjustment. This classification shall include all those existing catch basins, manholes, inlets and valve vaults which are to be adjusted to grade where 2 ft (600 mm) or less of masonry will be either added, removed or rebuilt to bring the specified casting to the finished grade of the proposed improvement.

- (b) **Reconstruction.** This classification shall include all those existing catch basins, manholes, inlets and valve vaults which must be reconstructed or which are to be adjusted to grade where more than 2 ft (600 mm) of masonry will be either added, removed, or rebuilt to bring the specified casting to the finished grade of the proposed improvement.

CONSTRUCTION REQUIREMENTS

602.04 Concrete. Cast-in-place concrete shall be constructed of Class SI concrete according to the applicable portions of Section 503.

Mortar shall be composed of one part masonry cement to three parts sand, by volume, based on dry materials. Mortar which has been mixed longer than 30 minutes or which has developed its initial set shall not be used.

Bottom concrete slabs shall be reinforced by either reinforcement bars or welded wire fabric. Construction requirements for reinforcement bars shall be according to Section 508.

602.05 Brick Masonry. Brick masonry shall be constructed in horizontal courses with a running bond using a header course every sixth course, or any standard bond of equivalent strength. The brick shall be laid in mortar.

602.06 Concrete Masonry Units. Concrete masonry units shall be constructed in horizontal courses with vertical joints broken. The units shall be laid in mortar.

602.07 Precast Reinforced Concrete Sections. Precast reinforced concrete sections shall be constructed in horizontal courses. The units shall be laid in mortar or sealed with external sealing bands, preformed flexible joint sealant, or mastic joint sealer. When mastic joint sealer is used, the material shall completely fill the joint after the units have been brought together. All precast units shall be installed on a 3 in. (75 mm) thick sand cushion. Handling holes shall be filled with a precast concrete plug and sealed with mastic or mortar. The plug shall not project beyond the inside surface after installation. When metal lifting inserts are used, their sockets shall be filled with mastic or mortar.

602.08 Steps. Steps, when required, shall be of cast gray iron conforming to the contract. Steps shall be embedded into the wall a minimum of 3 in. (75 mm) but shall not be extended on the outside of the structure. Steps of other design and material that conform to the minimum requirements shown on the plans may be used when approved by the Engineer.

602.09 Wooden Baffles. Wooden baffles, when required for drainage structures, shall be constructed of pine, fir, spruce, larch, or cedar No. 4 common board (utility), S4S, untreated.

602.10 Flat Slab Tops. Flat slab tops shall be provided when shown on the plans.

602.11 Furnishing and Placing Castings. Furnishing and placing of castings shall be as follows.

- (a) **Furnishing.** When specified, new castings, including frames, grates and lids, shall be according to Article 604.03.
- (b) **Placing for Rigid Pavements.** Castings placed on concrete or masonry surfaces shall be set in full mortar beds. Castings shall be set to the finished pavement elevation so no subsequent adjustment will be necessary. Lifting devices will be approved by the Engineer.
- (c) **Placing for Flexible Pavements.** The structures shall be constructed or adjusted to an elevation which will match the cross section of the subgrade.

After the base course and binder course have been placed, and prior to placing the surface course where there is no binder course, the structures shall be adjusted to grade by removing the binder and base course adjacent to and for a distance not exceeding 12 in. (300 mm) outside the base of the castings. After the structures have been adjusted, the castings shall be set in full mortar beds. Castings shall be set to the finished pavement elevation so that no subsequent adjustment will be necessary, and the space around the casting shall be filled with Class SI concrete, or a HMA surface or binder course material to the elevation of the surface of the base course or binder course. If Class SI concrete is used, it shall be cured for a period of 72 hours. If surface or binder course material is used, it shall be placed in 3 in. (75 mm) layers at the temperature requirements for the placing of surface or binder course and compacted with a pneumatic tamper.

602.12 Excavation and Backfilling. In order to permit the joints to be mortared properly and to permit proper compaction of the backfill material, the excavation shall be made to a diameter of at least 6 in. (150 mm) greater than the diameter of the structure.

The space between the sides of the excavation and the outer surfaces of the catch basin, manhole, inlet or valve vault shall be backfilled with sand or stone screenings, when these structures are in the subgrade or if the nearest point of the excavation for these structures falls within 2 ft (600 mm) of the pavement edge. When the structure falls beyond these limits, other backfilling material may be used with the approval of the Engineer.

The backfill shall be compacted according to Article 550.07.

602.13 Inlet and Outlet Pipes. Pipe or tile placed in the masonry for inlet or outlet connections shall extend through the walls and beyond the outside surfaces of the walls a sufficient distance to allow for connections, and the masonry shall be carefully constructed around them so as to prevent leakage along the outer surfaces.

602.14 Curing and Protection. After the masonry work is completed, it shall be kept moist and protected from the elements for a period of not less than 48 hours.

602.15 Cleaning. All catch basins, manholes, inlets, and similar structures newly constructed, adjusted or reconstructed under the contract, shall be cleaned of

any accumulation of silt, debris, or foreign matter of any kind, and shall be free from such accumulations at the time of final inspection.

602.16 Basis of Payment. When new construction is specified, this work will be paid for at the contract unit price per each for CATCH BASINS, MANHOLES, INLETS, DRAINAGE STRUCTURES, or VALVE VAULTS, of the type or type and diameter specified, and with the type of frame and grate or frame and lid specified or median inlet number specified.

When adjustment or reconstruction is specified and existing frames, grates, and lids are to be used, this work will be paid for at the contract unit price per each for CATCH BASINS TO BE ADJUSTED, CATCH BASINS TO BE RECONSTRUCTED, MANHOLES TO BE ADJUSTED, MANHOLES TO BE RECONSTRUCTED, INLETS TO BE ADJUSTED, INLETS TO BE RECONSTRUCTED, VALVE VAULTS TO BE ADJUSTED, or VALVE VAULTS TO BE RECONSTRUCTED.

When adjustment or reconstruction is specified and new frames, grates, lids or median inlets are to be used, this work will be paid for at the contract unit price per each for CATCH BASINS TO BE ADJUSTED WITH NEW FRAME AND GRATE or LID, of the type specified, or CATCH BASINS TO BE ADJUSTED WITH NEW MEDIAN INLET, of the number specified; CATCH BASINS TO BE RECONSTRUCTED WITH NEW FRAME AND GRATE or LID of the type specified, or CATCH BASINS TO BE RECONSTRUCTED WITH NEW MEDIAN INLET of the number specified; MANHOLES TO BE ADJUSTED WITH NEW FRAME AND GRATE or LID of the type specified, or MANHOLES TO BE ADJUSTED WITH NEW MEDIAN INLET of the number specified; MANHOLES TO BE RECONSTRUCTED WITH NEW FRAME AND GRATE or LID of the type specified, or MANHOLES TO BE RECONSTRUCTED WITH NEW MEDIAN INLET of the number specified; INLETS TO BE ADJUSTED WITH NEW FRAME AND GRATE or LID of the type specified, or INLETS TO BE ADJUSTED WITH NEW MEDIAN INLET of the number specified; INLETS TO BE RECONSTRUCTED WITH NEW FRAME AND GRATE or LID of the type specified, or INLETS TO BE RECONSTRUCTED WITH NEW MEDIAN INLET of the number specified; VALVE VAULTS TO BE ADJUSTED WITH NEW FRAME AND CLOSED LID of the type specified; or VALVE VAULTS TO BE RECONSTRUCTED WITH NEW FRAME AND CLOSED LID of the type specified.

Additional reinforcement, when required for Type 15 Frames and Lids, will be included in the unit bid price of the type of structure specified.

Excavation in rock will be measured and paid for according to Section 502.

SECTION 603. ADJUSTING FRAMES AND GRATES OF DRAINAGE AND UTILITY STRUCTURES

603.01 Description. This work shall consist of adjusting the frames, with grates or lids, of existing drainage and utility structures.

603.02 Materials. Materials shall be according to following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Building Brick (Made from Clay or Shale)	1041.01
(c) Concrete Brick	1042
(d) Concrete Masonry Units	1042
(e) Precast Reinforced Concrete Manhole Sections	1042
(f) Gray Iron Castings	1006.14
(g) Ductile Iron Castings	1006.15
(h) Structural Steel	1006.04
(i) Reinforcement Bars and Welded Wire Fabric	1006.10

CONSTRUCTION REQUIREMENTS

603.03 Two-Course Hot-Mix Asphalt (HMA) Construction. The existing pavement adjacent to and for a distance not exceeding 12 in. (300 mm) outside the base of the casting to be adjusted shall be broken sufficiently to permit its removal. The existing pavement shall be broken and the grates adjusted just prior to placing the surface course. If the existing pavement is broken prior to placing the first course, it shall not be removed until the first course has been placed and compacted. Where a casting is enclosed in a concrete platform, the entire platform shall be broken, removed and replaced.

Prior to placing the first course, the exposed surface of each casting shall be coated with an approved release agent to prevent the HMA from adhering to it. After the first course has been placed and compacted, the HMA over each drainage or utility structure and the existing pavement adjacent to the drainage or utility structure shall be removed. The broken pavement and HMA from these areas shall be disposed of by the Contractor according to Article 202.03.

The frames shall then be adjusted to the finished pavement elevation according to the applicable portions of Section 602.

603.04 Single-Course HMA Construction. Prior to placing the HMA, the existing pavement adjacent to and for a distance not exceeding 12 in. (300 mm) outside the base of the casting to be adjusted shall be broken, removed and disposed of by the Contractor according to Article 202.03.

The frames shall then be adjusted to the finished pavement elevation according to the applicable portions of Section 602.

603.05 Replacement of Existing Flexible Pavement. After the castings have been adjusted, the surrounding space shall be filled with Class SI concrete, or HMA surface or binder course material to the elevation of the surface of the base course or the binder course. If Class SI concrete is used, it shall be cured for a period of not less than 72 hours. If HMA is used, it shall be placed in 3 in. (75 mm) layers at the required temperature and compacted with a pneumatic tamper.

Art. 603.06

Frames, Grates, and Median Inlets

603.06 Replacement of Existing Rigid Pavement. After the castings have been adjusted, the pavement and HMA that was removed, shall be replaced with Class SI concrete not less than 9 in. (225 mm) thick.

The surface of the Class SI concrete shall be constructed flush with the adjacent surface. Class SI concrete shall be cured for a period of not less than 72 hours.

603.07 Protection Under Traffic.

After the casting has been adjusted and the Class SI concrete has been placed, the work shall be protected by a barricade and 2 lights for at least 72 hours. Before final surfacing operations have been started in the immediate vicinity of the structure, a temporary hot-mix or cold-mix asphalt mixture shall be placed around the casting, flush with its surface and decreasing to a featheredge in a distance of 2 ft (600 mm) around the entire surface of the casting. This mixture shall remain in place until surfacing operations are undertaken within the immediate area of the structure. Prior to placing the surface course, the temporary mixture shall be removed and disposed of by the Contractor according to Article 202.03.

603.08 Adjusting Rings.

As an option to Articles 603.03 through 603.07, the adjustment of frames and grates may be accomplished through the use of adjusting rings that fit on top of the frame. These adjusting rings shall be fabricated as a one-piece assembly from gray iron, ductile iron, or structural steel. They shall provide a structural capacity equal to or greater than the existing frame and shall not affect the opening size or surface appearance. The rings shall have a device for positively positioning and fastening the ring to the existing frame to prevent movement under traffic.

603.09 Basis of Payment.

This work will be paid for at the contract unit price per each for FRAMES AND GRATES TO BE ADJUSTED or FRAMES AND LIDS TO BE ADJUSTED.

SECTION 604. FRAMES, GRATES, AND MEDIAN INLETS

604.01 Description.

This work shall consist of furnishing, and installing frames, grates, lids, covers, and median inlets where such items are not included in the cost of the drainage or utility structures involved.

604.02 Materials.

Materials shall be according to the following.

Item	Article/Section
(a) Gray Iron Castings	1006.14
(b) Structural Steel	1006.04
(c) Ductile Iron Castings	1006.15
(d) Portland Cement Concrete	1020
(e) Reinforcement Bars and Welded Wire Fabric	1006.10

604.03 Materials Permitted.

The materials permitted for fabrication of the various types of frames, lids, grates and the various numbers of median inlets shall be according to the following.

Type or Number	Frame	Grate	Lid	Cover
1	Gray Iron		Gray Iron or Ductile Iron	
3 & 3V	Gray Iron	Gray Iron or Ductile Iron		
4	Gray Iron	Gray Iron or Ductile Iron		
5	Gray Iron		Gray Iron or Ductile Iron	
6	Gray Iron	Gray Iron or Ductile Iron		
7		Gray Iron or Ductile Iron		
8		Gray Iron or Ductile Iron		
9	Gray Iron	Gray Iron or Ductile Iron		
10	Gray Iron	Gray Iron or Ductile Iron		
11&11V	Gray Iron	Gray Iron or Ductile Iron		
12	Gray Iron	Gray Iron or Ductile Iron		
15	Gray Iron		Gray Iron or Ductile Iron	
20	Gray Iron or Ductile Iron	Gray Iron or Ductile Iron*		
21	Gray Iron or Ductile Iron	Gray Iron or Ductile Iron*		
22	Gray Iron or Ductile Iron	Gray Iron or Ductile Iron*		
23	Gray Iron or Ductile Iron	Gray Iron or Ductile Iron*		
24	Gray Iron or Ductile Iron	Gray Iron or Ductile Iron*		
Median Inlet (STD 604101)	Gray Iron	Ductile Iron		
Median Inlet (STD 604106)	Gray Iron	Ductile Iron		
2A & 2B		Gray Iron or Ductile Iron		Gray Iron or Ductile Iron
A & B		Gray Iron or Ductile Iron		

*Safety bars for the grates shall be of ductile iron.

CONSTRUCTION REQUIREMENTS

604.04 General. Frames placed on concrete or masonry surfaces shall be set in full mortar beds. The mortar shall be mixed in proportions of one part cement to three parts sand, by volume based on dry materials. Castings shall be set accurately to the finished elevation so that no subsequent adjustment will be necessary.

For frames and grates, Type 6 and 12, a two piece frame may be used with the approval of the Engineer.

For frames and grates, Type 20, 21, and 22, the notch in the grate and the 9/16 in. (14 mm) diameter holes in the frame are for the insertion of one galvanized 1/2 in. (M12) diameter bolt and nut. The bolt and nut shall be placed as directed by the Engineer to provide for correct replacement of the grates during maintenance operations.

When frames and grates, Type 21, is used in conjunction with a precast concrete barrier, a gap of at least 2 ft (600 mm) on both sides of the casting shall be provided to permit cast-in-place barrier to be constructed to incorporate the barrier box.

When median inlets (STD 604101 and STD 604106) are specified, the concrete apron shall be constructed of Class SI concrete and shall be reinforced with welded wire fabric consisting of 6 x 6 in. (150 x 150 mm) mesh, No. 4 (5.7 mm) wire, weighing 58 lb/100 sq ft (2.8 kg/sq m).

Additional reinforcement, when specified for Type 15 frames and lids, will be included in the unit bid price of the type of structure specified.

604.05 Basis of Payment. This work will be paid for at the contract unit price per each for FRAMES, GRATES, FRAMES AND GRATES, FRAMES AND LIDS, and GRATES AND COVERS, of the type or types specified, and at the contract unit price per each for MEDIAN INLETS of the number specified.

The unit price bid for median inlets shall include castings, concrete, and reinforcement for constructing the concrete apron.

The unit price bid for frames and lids, Type 15, shall include the extra form work required by the special construction under CASE I or CASE II, and no additional compensation will be allowed.

SECTION 605. REMOVING OR FILLING EXISTING MANHOLES, CATCH BASINS, AND INLETS

605.01 Description. This work shall consist of removing or filling existing manholes, catch basins, and inlets.

605.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Building Brick (Made from Clay or Shale)	1041.01
(c) Concrete Brick	1042

CONSTRUCTION REQUIREMENTS

605.03 Removing Existing Manholes, Catch Basins, and Inlets. Existing manholes, catch basins, and inlets designated to be removed at locations where the existing inlet and/or outlet pipes are to be abandoned, shall be removed for the full depth of structure. If the abandoned pipes are not designated to be removed, the ends of the pipe at the structure shall be sealed with Class SI concrete or brick and mortar. After the concrete or mortar has set, the hole formed by removal of the structure shall be backfilled with sand and the sand compacted.

Existing manholes, catch basins, and inlets designated to be removed at locations where flow is to be maintained in the existing storm sewer system or a proposed storm sewer is to be connected to the existing system, shall be removed to a depth of at least 4 in. (100 mm) below the bottom of the storm sewer system. All debris in the structure below the storm sewer shall be removed and replaced with compacted sand to the approximate elevation of the bottom of the sewer. The existing storm sewer shall then be connected to maintain flow with pipe of the same kind and size as the existing pipe, or the proposed storm sewer shall be connected to the existing system, and the joints sealed. If a proper connection cannot be made at a joint in the existing sewer, a collar of Class SI concrete shall be used to seal the joint. The hole formed by the removal of the structure shall then be backfilled with sand and the sand compacted.

605.04 Filling Existing Manholes, Catch Basins, and Inlets. The tops of all existing manholes, catch basins, and inlets to be filled shall be removed to an elevation of at least 3 in. (75 mm) below the earth subgrade of the proposed improvement. All inlet and/or outlet connections shall be securely sealed with Class SI concrete or brick and mortar. After the concrete or mortar has set, the existing structure shall be filled with sand and the sand compacted.

605.05 Disposal of Excess Material. All material resulting from the filling or removing of existing manholes, catch basins, and inlets shall be disposed of by the Contractor according to Article 202.03.

605.06 Basis of Payment. The work of removing existing manholes, catch basins, and inlets at locations where the existing inlet and/or outlet pipes are to be

abandoned will be paid for at the contract unit price per each for REMOVING MANHOLES, REMOVING CATCH BASINS, or REMOVING INLETS.

The work of removing existing manholes, catch basins, and inlets at locations where flow is to be maintained in the storm sewer system will be paid for at the contract unit price per each for REMOVING MANHOLES TO MAINTAIN FLOW, REMOVING CATCH BASINS TO MAINTAIN FLOW, or REMOVING INLETS TO MAINTAIN FLOW.

The work of filling existing manholes, catch basins, and inlets will be paid for at the contract unit price per each for FILLING MANHOLES, FILLING CATCH BASINS or FILLING INLETS.

SECTION 606. CONCRETE GUTTER, CURB, MEDIAN, AND PAVED DITCH

606.01 Description. This work shall consist of constructing concrete curb, concrete gutter, combination concrete curb and gutter, concrete median, or paved ditch.

606.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Reinforcement Bars and Fabric	1006.10
(c) Preformed Expansion Joint Fillers	1051
(d) Protective Coat	1023
(e) Dowel Bars	1006.11
(f) Polysulfide Joint Sealant	1050.03

606.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Forms	1103.05

CONSTRUCTION REQUIREMENTS

606.04 Excavation. The subgrade shall be excavated according to the cross section shown on the plans. All unsuitable material shall be removed and replaced with suitable material, and the subgrade shall be compacted and finished to a firm, smooth surface.

606.05 Forms. Forms shall be securely staked, braced and held firmly to the required line and grade, and shall be tight. All forms shall be cleaned and oiled before the concrete is placed against them.

With the approval of the Engineer, a slipform machine may be used. If a slipform paver is used, the concrete slump shall be adjusted to meet the tolerances for the type of work being performed. Vertical faces may be battered at the rate of six percent from vertical to aid in slipform operations.

606.06 Placing Concrete. The improved subgrade shall extend to the back of the curb. The subgrade and forms will be checked and approved by the Engineer before the concrete is placed. The subgrade shall be moistened prior to concrete placement. The concrete shall be thoroughly tamped and spaded or mechanically vibrated and finished smooth and even. Before the concrete is given the final finish, the surface of the curb, curb and gutter, gutter, or median will be checked with a 10 ft (3 m) straightedge, and any irregularities of more than 1/4 in. in 10 ft (6 mm in 3 m) shall be eliminated.

606.07 Concrete Gutter, Curb, and Curb and Gutter. Joints in concrete gutter, curb, and combination curb and gutter shall be a continuation of the joints in the adjacent portland cement concrete pavement, base course, base course widening, or shoulder. Expansion joints adjacent to drainage castings may be placed in prolongation with other joint types.

When concrete gutter, curb, and combination curb and gutter are constructed adjacent to flexible pavement or shoulders, joints shall be constructed according to the details shown on the plans.

At points where the proposed or existing sidewalk or driveway pavement occupies the entire space between the proposed curb and an adjacent building or permanent structure, 1 in. (25 mm) preformed expansion joint shall be placed between the sidewalk, building, or driveway pavement and the proposed curb. The expansion joint material shall extend the entire depth of the sidewalk, or driveway pavement, or to such depth as will allow 1 in. (25 mm) expansion between the proposed curb and adjacent sidewalk, building or driveway pavement.

Longitudinal construction, transverse contraction, and transverse expansion joints shall be constructed according to the applicable portions of Article 420.05. Contraction joints shall be sawed to a depth equal to 1/3 the thickness of the gutter flag and to a width of not less than 1/8 in. (3 mm). The expansion joint filler material shall be cut to the exact cross section of the gutter, curb, or combination curb and gutter. Dowel bars for expansion and contraction joints in combination concrete curb and gutter shall be spaced as shown on the plans, except only one dowel bar will be required at a joint if the width of the gutter is less than 18 in. (450 mm).

Transverse contraction and longitudinal construction joints shall be sealed according to Article 420.12, except transverse joints in concrete curb and gutter shall be sealed with polysulfide joint sealant.

When combination concrete curb and gutter is constructed across alleys or private drives, the top of curbs shall be depressed according to the details shown on the plans. The transition from full height curb to depressed curb shall be made in a distance equal to at least four times the difference in height from the full height to the depressed curb.

Where HMA base course or base course widening is specified to extend under the curb and gutter, the curb and gutter may be poured full depth of the pavement in lieu of the base course.

Areas of adjacent portland cement concrete pavement, base course, or base course widening less than 12 in. (300 mm) in width shall be constructed monolithically

with the curb or combination curb and gutter. Areas of adjacent portland cement concrete pavement, base course, or base course widening greater than 12 in. (300 mm) in width may be constructed monolithically with the curb or combination curb and gutter. When monolithic construction is performed, the following shall apply.

- (a) Tie bars between the portland cement concrete pavement and the curb or combination curb and gutter will not be required.
- (b) Tie bars between the portland cement concrete base course or base course widening and the curb or combination curb and gutter will be required. The tie bars shall be held in the proper position by support pins or placed by approved mechanical means.
- (c) Pavement reinforcement, when required in the pavement, shall be extended laterally to within 3 to 5 in. (75 to 125 mm) from the back of the curb.
- (d) The longitudinal joint between the portland cement concrete pavement, base course, or base course widening and the curb or combination curb and gutter shall not be constructed.

Transition from one type of gutter, curb, or curb and gutter to another type shall be constructed according to the details shown on the plans.

606.08 Inlets, Entrances, and Outlets for Gutter and Curb and Gutter.

Inlets, entrances, and outlets for concrete gutter, and outlets for combination concrete curb and gutter shall be constructed according to the details shown on the plans.

The longitudinal and transverse joints shall be according to Article 606.07.

Pipe drains for outlets of the drop-box type shall be either corrugated steel or aluminum alloy pipe constructed according to the applicable portions of Section 601. The grates and covers shall be according to the applicable portions of Section 604.

606.09 Concrete Medians. Concrete medians shall be constructed at the locations, of the types, and according to the details shown on the plans.

For Type P surface median, grooves 1 in. (25 mm) deep shall be formed in the plastic concrete at 10 ft (3 m) maximum intervals both transversely and longitudinally. Grooves also shall be formed at the corner points of all holes boxed out for sign and signal posts. A 3/4 in. (20 mm) diameter plastic tube shall be installed through the back of the curb at 100 ft (30 m) intervals on the low side or sides of the median and two at the low end to provide drainage.

Aggregate fill, when required under paved median, shall be gradation CA 7, CA 8, CA 11, CA 13, CA 14, CA 15, or CA 16 according to Article 1004.05 and shall be placed in layers 4 in. (100 mm) thick and compacted.

Portland cement concrete pavement, base course, or base course widening less than 12 in. (300 mm) in width that is directly adjacent to concrete median shall be constructed monolithically with the median, but the area will be included in the measured area of the adjacent pavement, base course, or base course widening.

The transverse joints in Type P surface median shall be expansion joints consisting of preformed expansion joint filler 3/4 in. (20 mm) thick, conforming to the full cross section of the median surface, and placed at intervals of 30 ft (9 m) in the median surface. At least one joint shall be constructed in each median island.

For all other types of median when constructed adjacent to portland cement concrete pavement, base course, or base course widening, transverse joints shall be in prolongation with joints in the pavement, base course, or base course widening and shall be of the same type, except that dowel bars or tie bars will not be required. For corrugated medians, the Contractor has the option of constructing the joints with 3/4 in. (20 mm) preformed expansion joint filler conforming to the full cross section of the median. When constructed adjacent to flexible pavement, transverse joints shall be contraction joints at 20 ft (6 m) intervals.

Contraction joints shall be formed by sawing to a depth of 1/3 the thickness of the median and sealed according to Article 420.12. Expansion joints shall be formed by placing 3/4 in. (20 mm) thick preformed expansion joint filler conforming to the full cross section of the median. When permitted by the Engineer, expansion joints may be substituted for contraction joints.

606.10 Paved Ditch. Paved ditch shall be constructed as shown on the plans.

Anchor walls shall be spaced at not more than 50 ft (15 m) intervals along the paved ditch. Anchor walls and the cut-off wall shall be constructed monolithically with the paved ditch.

At the option of the Contractor, No. 3 (No. 10) reinforcing bars placed at 12 in. (300 mm) centers longitudinally in the paved ditch and vertically in the anchor and cut-off walls may be used in lieu of the welded wire fabric.

A 1/2 in. (13 mm) thick preformed joint filler shall be placed at the junction of paved ditch with any other structure.

606.11 Finishing. All exposed surfaces shall be finished smooth and even, and given a light brush finish while the concrete is still workable. The edges shall be rounded with approved finishing tools having the radii shown on the plans.

Forms shall be removed within 24 hours after the concrete has been placed and minor defects shall be filled with mortar consisting of one part portland cement to two parts fine aggregate.

606.12 Protective Coat. Protective coat, when required, shall be constructed according to Article 420.18.

606.13 Backfill. After the concrete has obtained the specified strength, the spaces in front and back of the construction shall be backfilled to the required elevation with suitable material, compacted, and neatly graded.

606.14 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirement for use of contract quantities shall be according to Article 202.07(a).
- (b) Measured Quantities. Concrete curb, concrete gutter, combination concrete curb and gutter, and paved ditch will be measured for payment in feet (meters) in the flow line of the gutter or paved ditch and along the face of concrete curb, which measurement will include drainage castings incorporated in various curbs and curbs and gutters but will exclude entrances, inlets, and outlets for gutters and outlets for combination curb and gutters. The lengths of transitions from one type of gutter or curb and gutter to another will be included in the measured quantities for the types having the largest cross sectional areas of concrete.

Areas of pavement, base course, or base course widening that are constructed monolithically with curb or combination curb and gutter will be included in the measured areas of the adjacent pavement, base course, or base course widening.

The various types of concrete median will be measured for payment in place and the area computed in square feet (square meters). Concrete curb and gutter around solid concrete median will not be measured separately for payment. Concrete curb and gutter around Type P median surface will be measured separately for payment in feet (meters). The areas of ramp noses will be included in the measured quantities of concrete medians in which they are included.

Concrete inlets, entrances and outlets for gutters, and outlets for combination curb and gutter will be measured for payment in place and the volume of concrete computed in cubic yards (cubic meters). Pipe drains for outlets of the drop-box type will be measured for payment according to Article 601.07. Tie bars will be measured according to Article 508.07.

606.15 Basis of Payment. Concrete gutter, curb, and combination curb and gutter will be paid for at the contract unit price per foot (meter) for CONCRETE GUTTER, CONCRETE CURB or COMBINATION CONCRETE CURB AND GUTTER, of the type specified.

Concrete median will be paid for at the contract unit price per square foot (square meter) for CORRUGATED MEDIAN; CONCRETE MEDIAN SURFACE, 4 INCH (100 MM) or CONCRETE MEDIAN, of the type specified. For solid concrete median the unit price will also include concrete curb and gutter.

Concrete inlets, entrances and outlets for gutter, and outlets for combination curb and gutter will be paid for at the contract unit price per cubic yard (cubic meter) for CLASS SI CONCRETE (OUTLET). Grates and covers used with drop-box type outlets will be paid for according to Article 604.05. Pipe drains for drop-box type outlets will be paid for according to Article 601.08.

Paved ditch will be paid for at the contract unit price per foot (meter) for PAVED DITCH, of the type specified.

Protective coat will be paid for according to Article 420.20.

Excavation required in the performance of the work will be measured and paid for according to Section 202.

SECTION 607. SLUICE GATE

607.01 Description. This work shall consist of furnishing, fabricating, transporting, and installing a sluice gate with all the necessary appurtenances.

607.02 Materials. Materials shall be according to AWWA C560 Section 4.3 - Materials.

CONSTRUCTION REQUIREMENTS

607.03 General. The sluice gate shall be constructed according to AWWA C560 Section 4.4 - General Design and Section 4.5 - Manufacture.

All wedges shall be provided with wedge adjusting screws and lock nuts.

All manual floor stands shall be provided with clear butyrate plastic pipe covers with mylar position indicators.

When required, a wall thimble shall be installed.

607.04 Painting. All cleaning, painting, and protecting of the sluice gate shall be according to AWWA C560 Section 4.4.13 - Painting. A finish coat of black asphalt base coating shall be applied in the field to all submerged parts. The lifting device shall be painted with a machinery enamel suitable for outdoor service.

607.05 Installation. The sluice gate shall be installed and tested according to AWWA C560 Section 4.6 - Installation and Field Testing.

607.06 Drawings and Manuals. Before any fabrication has begun, the Contractor shall submit four complete sets of shop drawings to the Engineer for approval.

Four copies of the manual giving complete information on installation, lubrication, and maintenance shall be provided to the Engineer by the Contractor.

607.07 Basis of Payment. This work will be paid for at the contract unit price per each for SLUICE GATE, of the type and size specified.

SECTION 608. FLAP GATES

608.01 Description. This work shall consist of furnishing, fabricating, painting, transporting, and installing a flap gate of the size, shape, and design head shown on the plans with all the necessary appurtenances.

608.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Flap Gate	1044
(b) Chemical Adhesive Resin System	1027

CONSTRUCTION REQUIREMENTS

608.03 Fabrication. Before fabrication of the component parts of the flap gate is initiated, shop drawings showing the dimensions and details required to locate and install the component assemblies shall be submitted for the Engineer's approval.

608.04 Installation. Prior to initiating installation of the flap gate, the Contractor shall provide the Engineer with four copies of a manual giving complete information on installation, lubrication, and maintenance of the flap gate.

The flap gate shall be installed according to the manufacturer's recommendations and as directed by the Engineer. The gate shall be installed in a plumb position with the axis of the hinge perpendicular to the centerline of the waterway opening.

The quantity and size of the fasteners shall be as recommended by the manufacturer. Flat back seat gates attached to concrete shall be mounted on anchor bolts and grouted in place. The anchor bolts shall be furnished with two nuts each to facilitate installation and alignment.

608.05 Basis of Payment. Flap gates will be paid for at the contract unit price per each for FLAP GATE, of the size specified.

SECTION 609. BRIDGE APPROACH PAVEMENT DRAINS

609.01 Description. This work shall consist of constructing bridge approach pavement drains according to the details shown on the plans.

609.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Gray Iron Castings.....	1006.14
(c) Ductile Iron Castings	1006.15
(d) Reinforcement Bars and Welded Wire Fabric	1006.10
(e) Bedding Layer (Note 1)	1004.01
(f) Precast Concrete Bridge Approach Drains	1042

Note 1. Gradation CA 6, CA 10, or CA 12 of D quality or better.

Steel frames shall be galvanized after fabrication according to the requirements of AASHTO M 111.

CONSTRUCTION REQUIREMENTS

609.03 Inlet Boxes. Cast-in-place inlet boxes shall be Class SI concrete according to the applicable portions of Section 503. A 3 in. (75 mm) thick bedding layer shall be provided under the full length and width of precast units.

609.04 Frames and Grates. Cast iron frames and grates shall be used. Grates shall seat firmly in the frame.

609.05 Pipe Drains. Pipe drains shall be according to the applicable portions of Section 601, except that the material shall be corrugated steel, aluminum alloy, or polyethylene (PE) pipe; sand bedding will not be required; and corrugated steel and aluminum alloy pipe shall have 2 ft (600 mm) couplings.

All pipe connections shall be watertight and all voids around the pipe drain entrance shall be sealed with mortar both inside and outside the inlet box.

When steel or aluminum pipe is used, the end section shall be of the same material as the pipe. When polyethylene (PE) pipe is used, the end section shall be steel or aluminum.

609.06 Thrust Blocks. Thrust blocks, when required, shall be cast-in-place of Class SI concrete. Thrust blocks will not be required when the difference in elevation between the inlet box invert and pipe drain outfall is less than 3 ft (900 mm).

609.07 Basis of Payment. Inlet boxes complete in place will be paid for at the contract unit price per each for TYPE B, C, or D INLET BOX STANDARD 609001 or TYPE B, C or D INLET BOX STANDARD 609006.

Pipe drains will be measured and paid for according to Section 601.

End sections will be measured and paid for according to Section 542.

Thrust blocks will be paid for at the contract unit price per each for CONCRETE THRUST BLOCKS.

SECTION 610. SHOULDER INLETS WITH CURB

610.01 Description. This work shall consist of constructing shoulder inlets with curb according to the details shown on the plans and as specified.

610.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Gray Iron Castings	1006.14
(c) Ductile Iron Castings	1006.15
(d) Structural Steel	1006.04
(e) Reinforcement Bars	1006.10
(f) Precast Concrete Shoulder Inlet	1042
(g) Reinforcement Bars and Welded Wire Fabric	1006.10

CONSTRUCTION REQUIREMENTS

610.03 Inlet Boxes. Inlet boxes shall be constructed according to Article 609.03.

610.04 Frames and Grates. Frames and grates shall be according to Article 609.04.

610.05 Pipe Drains. Pipe drains shall be constructed according to Article 609.05.

610.06 Thrust Blocks. Thrust blocks shall be constructed according to Article 609.06.

610.07 Portland Cement Concrete Slab. The portland cement concrete slab shall be constructed of Class PV concrete according to the applicable portions of Section 483. Construction requirements for reinforcement bars shall be according to Section 508.

When shoulder inlets are constructed in conjunction with new HMA shoulders, the HMA shoulder shall be constructed first and then sawed full depth and removed in the area of the portland cement concrete slab. The area of HMA shoulder removed for the construction of the portland cement concrete slab will be included in the area of HMA shoulders measured for payment.

When the portland cement concrete slab is constructed in conjunction with new portland cement concrete shoulders, the slab may be constructed separately or monolithically with the shoulders at the option of the Contractor.

The lengths of reinforcement bars used in the portland cement concrete slab shall be such as to accommodate the lengths, width, and spacing shown on the plans.

610.08 Shoulder Curb. When shoulder inlets are constructed in conjunction with new HMA shoulders, a HMA curb shall be constructed according to Section 661. When shoulder inlets are constructed in conjunction with new portland cement concrete shoulders, a portland cement concrete shoulder curb shall be constructed according to Section 662.

610.09 Basis of Payment. Inlet boxes, complete in place, will be paid for at the contract unit price per each for TYPE E INLET BOX, STANDARD 610001 or TYPE F INLET BOX, STANDARD 610001.

Pipe drains will be measured and paid for according to Section 601.

End sections will be measured and paid for according to Section 542.

Thrust blocks will be paid for according to Article 609.07.

The portland cement concrete slab will not be paid for separately but shall be considered as included in the cost of the inlet box.

Shoulder curb will be measured and paid for according to Section 661 or Section 662.

SECTION 611. TREATMENT OF EXISTING FIELD TILE SYSTEMS

611.01 Description. This work shall consist of locating and treating existing field tile systems within the limits of the right-of-way.

CONSTRUCTION REQUIREMENTS

611.02 Locating Existing Field Tile. Existing field tile in those areas where they are reported or suspected to exist shall be located by constructing an exploration trench according to Section 213.

611.03 Existing Field Tile Intercepted by Backslopes. Existing field tile which are intercepted by the backslopes of the roadway after the ditches have been cut shall have the upstream ends tightly sealed with Class SI concrete or brick and mortar.

If specified on the plans, the existing field tile within the limits of the pavement and paved shoulders shall be removed or crushed. Removing or crushing existing field tile shall be accomplished by constructing exploration trench along the line of the tile. All trenches cut for the purpose of removing or crushing existing tile within the limits of 2 ft (600 mm) outside the proposed pavement and paved shoulders shall be backfilled to the existing ground line in fill sections and to the elevation of the earth subgrade in cut sections with trench backfill according to Section 208 and compacted according to Article 550.07.

Pipe drains, according to the applicable portions of Section 601, shall be used for the terminal 10 ft (3 m) of the existing field tile where it is outletted into the roadway

ditch. The pipe drain shall be a single length section of a diameter equal to the diameter of the existing field tile plus 2 in. (50 mm), but not less than 6 in. (150 mm).

Pipe drains outletting into a roadway ditch shall have a concrete headwall constructed at the outlet end according to the details shown on the plans. The headwall shall be constructed of Class SI concrete according to the applicable portion of Section 503.

611.04 Field Tile Not Intercepted by Backslopes. Storm sewer shall be used to replace existing field tile within the right-of-way at locations where the existing tile crosses under the roadway and below the roadway ditches, and shall be constructed according to Section 550.

Storm sewer protected shall be used to replace existing field tile within the right-of-way at locations where the existing tile crosses under the roadway and below the roadway ditch. The kinds of material permitted for storm sewer protected shall be Class A according to Article 550.03. Additional protection shall be provided for the storm sewer at roadway ditches by constructing a concrete slab or paved ditch section over the pipe according to the details shown on the plans. The concrete slab shall be used whenever the cover over the slab at the bottom of the ditch is 4 in. (100 mm) or more. The paved ditch section shall be used when the cover is less than 4 in. (100 mm). The concrete slab and paved ditch section shall be constructed of Class SI concrete according to the applicable portions of Section 503.

Storm sewer (special) shall be used to replace existing field tile within the right-of-way at locations where the existing tile does not cross under the roadway and is not outlet into the roadway ditch. The kinds of material permitted for storm sewer (special) shall be according to Article 550.03 for storm sewers, Type 2. Storm sewer (special) shall be constructed according to Section 550, except that in lieu of the sand bedding the pipe may be installed according to Article 601.03 and joints between pipe sections shall not be sealed.

At locations where storm sewer (special) is outletted into a headwall according to Article 601.05 for pipe drains shall be constructed at the outlet end.

611.05 Field Tile Junction Vaults. Field tile junction vaults, shall be used at locations where two or more drain lines intersect, where a sharp directional change of flow is required, or where storm sewer or storm sewer (special) connects to existing field tile. Field tile junction vaults shall be constructed according to the details shown on the plans and the applicable portions of Section 602. When required, a sand cushion shall be placed as shown on the plans. Frame and grate, when required, shall be cast iron. All junctions between pipes and vault shall be sealed with mortar consisting of one part portland cement to two parts sand.

611.06 Method of Measurement. Exploration trench for locating existing field tile and for removing or crushing existing field tile will be measured for payment in feet (meters) of actual trench constructed.

Storm sewers protected and storm sewers (special) of the various diameters will be measured for payment in place in feet (meters).

Concrete headwalls, concrete slabs, and paved ditch sections will be measured for payment in place and the volume computed in cubic yards (cubic meters).

611.07 Basis of Payment. Locating existing field tile and removing or crushing existing field tile will be paid for at the contract unit price per foot (meter) for EXPLORATION TRENCH 52 IN. (1.3 M) DEPTH.

Pipe drains will be measured and paid for according to Section 601.

Storm sewer protected will be paid for at the contract unit price per foot (meter) for STORM SEWERS PROTECTED, CLASS A, of the type and diameter specified.

Storm sewer (special) will be paid for at the contract unit price per foot (meter) for STORM SEWERS (SPECIAL), of the diameter specified.

Concrete headwalls, concrete slabs, and paved ditch sections required for this work will be paid for at the contract unit price per cubic yard (cubic meter) for MISCELLANEOUS CONCRETE.

Field tile junction vaults will be paid for at the contract unit price per each for FIELD TILE JUNCTION VAULTS, of the diameter specified.

Trench backfill will be measured and paid for according to Section 208.

Excavation in rock will be measured and paid for according to Section 502.

Removal and replacement of unsuitable material below bedding grade will be paid for according to Article 109.04.

Sealing the ends of existing field tile will not be paid for as a separate item, but shall be considered as included in the unit prices bid for the various pay items of work involved.

SAFETY RELATED ITEMS

SECTION 630. STEEL PLATE BEAM GUARDRAIL

630.01 Description. This work shall consist of furnishing and erecting steel plate beam guardrail and posts.

630.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Steel Plate Beam Guardrail	1006.25
(b) Wood Posts and Wood Block	1007.01, 1007.02, 1007.06
(c) Steel Posts, Blockouts, Restraints and Wire Rope for Guardrail	1006.23
(d) Preservative Treatment	1007.12
(e) Portland Cement Concrete	1020
(f) Reinforcement Bars	1006.10
(g) Plastic Blockouts (Note 1)	
(h) Grout (Note 2)	1024.01

Note 1. Plastic blockouts may be used in lieu of wood blockouts for steel plate beam guardrail. The plastic blockouts shall be the minimum dimensions shown on the plans and shall be on the Department's approved list.

Note 2. The grout mixture shall be one part cement and two parts sand mixed with water.

CONSTRUCTION REQUIREMENTS

630.03 General. Steel plate beam guardrail and posts shall be furnished and erected as shown on the plans and as specified herein. All holes in posts and blockouts shall be 3/4 in. (19 mm). All rail elements shall be lapped in the direction of traffic in the adjacent lane.

Load tests shall be conducted on ten percent of all anchor bolts used in guardrail installation. The tests shall be conducted in the presence of the Engineer. The equipment and method used shall meet the approval of the Engineer. The minimum test load shall be 7500 lb for 3/4 in. (33 kN for M20) diameter bolts and 3000 lb for 5/8 in. (13 kN for M16) diameter bolts in direct pull. For each anchor bolt that fails the test, two more anchor bolts selected by the Engineer shall be tested. Each anchor bolt that fails to meet the test requirements shall be reset, or removed and the hole drilled deeper and reset, and retested until the anchor bolt passes the local test.

630.04 Fabrication. The plates for the rail element shall be blanked to proper shape, fabricated, and ready for assembly when received. No punching, drilling, cutting, or welding will be permitted in the field.

Where steel plate beam guardrail is constructed on curves which have a radius of 150 ft (45 m) or less, the rail element plate shall be shop curved to the proper radius with the road side of the rail either concave or convex as required.

Plates in lap splices shall make contact throughout the entire area of the splice. All bolts in curved or deformed portions of the rail element shall be fabricated in such a manner that satisfactory bearing is obtained under the bolt head.

Rail elements shall be furnished in nominal lengths of either 12 ft 6 in. or 25 ft 0 in. (3.8 m or 7.6 m).

630.05 Posts. Posts shall be as follows.

- (a) Wood Posts. Wood posts and blocks shall be treated. The posts and blocks shall be cut to the proper dimensions before treatment. No cutting of the posts or blocks will be permitted after treatment. Posts shall be erected according to Article 634.05.
- (b) Steel Posts. Steel posts may be driven by hand or mechanical methods provided they are protected by a suitable driving cap and the earth around the posts compacted, if necessary, after driving. When steel posts are

driven to incorrect alignment or grade, they shall be removed and set according to Article 634.05.

Only steel posts shall be used when the guardrail is mounted on existing culverts. When it is necessary to shorten the posts in the field, the lower portion shall be cut off in a manner to provide a smooth cut with minimum damage to the galvanizing. Cut areas shall be repaired according to the requirements of AASHTO M 36.

630.06 Shoulder Stabilization at Guardrail. Shoulder stabilization shall be constructed at the locations of steel plate beam guardrail installation according to the details shown on the plans. On new construction projects, the material used in the shoulder stabilization shall be the same as that used in the adjacent paved shoulder. On shoulder resurfacing projects, the material used in the shoulder stabilization shall be the same as that used for the shoulder resurfacing.

When portland cement concrete is used, shoulder stabilization shall be constructed according to the applicable portions of Section 483. The shoulder stabilization shall be constructed simultaneously with the adjacent portland cement concrete shoulder. Guardrail posts shall be driven through round blockouts or holes cored in the completed shoulder stabilization. The void around each post shall be backfilled with earth or aggregate and capped with 3 in. (75 mm) of hot-mix asphalt (HMA) or grout.

When HMA is used, shoulder stabilization shall be constructed according to the applicable portions of Section 482. On new construction, the shoulder stabilization shall be constructed simultaneously with the HMA shoulder. On shoulder resurfacing projects, the portion of the shoulder stabilization below the surface of the existing paved shoulder shall be placed and compacted separately. The guardrail posts shall be driven through holes cored in the completed shoulder stabilization. The void around each post shall be backfilled with earth or aggregate and capped with 3 in. (75 mm) of HMA or grout.

When driving guardrail posts through existing shoulders, shoulder stabilization, or other paved areas, the posts shall be driven through cored holes. The void around each post shall be backfilled with earth or aggregate and capped with 3 in. (75 mm) of HMA or grout.

630.07 Method of Measurement. This work will be measured for payment in feet (meters) along the top edge of the rail elements, continuous through laps and splices. Two rails attached to a single post will be measured once as double rail (Type D).

Steel plate beam guardrail mounted on existing culverts will be measured for payment in feet (meters) extending from center to center of the first post driven adjacent to the structure.

Portland cement concrete shoulder stabilization at guardrail will be measured for payment according to Article 483.09.

HMA shoulder stabilization at guardrail will be measured for payment according to Article 482.07.

Excavation in rock will be measured for payment according to Article 502.12.

Long-span guardrail over culvert will be measured for payment in feet (meters).

630.08 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for STEEL PLATE BEAM GUARDRAIL, TYPE A, 6 FOOT (1.83 M) POSTS; STEEL PLATE BEAM GUARDRAIL, TYPE A, 9 FOOT (2.74 M) POSTS; STEEL PLATE BEAM GUARDRAIL, TYPE B, 6 FOOT (1.83 M) POSTS; STEEL PLATE BEAM GUARDRAIL, TYPE B, 9 FOOT (2.74 M) POSTS; or STEEL PLATE BEAM GUARDRAIL, TYPE D, 6 FOOT (1.83 M) POSTS.

When end sections are specified, they will not be paid for as a separate item, but shall be considered as included in the unit price for steel plate beam guardrail.

Steel plate beam guardrail mounted on existing culverts will be paid for at the contract unit price per foot (meter) for STEEL PLATE BEAM GUARDRAIL, ATTACHED TO STRUCTURES.

Portland cement concrete shoulder stabilization at guardrail will be paid for according to Article 483.10.

HMA shoulder stabilization at guardrail will be paid for according to Article 482.08.

Excavation in rock will be paid for according to Article 502.13.

Steel plate beam guardrail incorporating long-span spacing will be paid for at the contract unit price per foot (meter) for LONG-SPAN GUARDRAIL OVER CULVERT, 12 FT 6 IN (3.8 M) SPAN; LONG-SPAN GUARDRAIL OVER CULVERT, 18 FT 9 IN (5.7 M) SPAN; or LONG-SPAN GUARDRAIL OVER CULVERT, 25 FT (7.6 M) SPAN.

SECTION 631. TRAFFIC BARRIER TERMINALS

631.01 Description. This work shall consist of furnishing and erecting traffic barrier terminals.

631.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Rail Element Plates, End Section Plates, and Splice Plates	1006.25
(b) Bolts, Nuts, Washers and Hardware	1006.25
(c) Wood Posts and Wood Blockouts	1007.01, 1007.02, 1007.06
(d) Preservative Treatment	1007.12
(e) Steel Posts	1006.23
(f) Rubrail, Structural Shapes, and Plates	1006.04
(g) Hollow Structural Tubing	1006.27(b)

CONSTRUCTION REQUIREMENTS

631.03 General. Traffic barrier terminals shall be furnished and erected as shown on the plans and as specified herein and constructed according to Articles 630.03 through 630.06.

631.04 Traffic Barrier Terminal Type 1, Special (Tangent) and Traffic Barrier Terminal Type 1, Special (Flared). These terminals shall meet the testing criteria contained in either NCHRP Report 350 or MASH. In addition to meeting the criteria in one or both of these references, the terminals shall be approved by the Department.

The terminal shall be installed according to the manufacturer's specifications and shall include all necessary transitions between the terminal and the item to which it is attached.

The terminal section shall provide a minimum length of need of 37.5 ft (11.4 m).

The terminal shall be delineated with a terminal marker direct applied. No other guardrail delineation shall be attached to the terminal section.

631.05 Traffic Barrier Terminal, Type 1B. The excavated area around the buried portion of the terminal shall be backfilled according to Article 502.10, except that granular material shall not be used.

631.06 Traffic Barrier Terminal, Type 5. The face of the guardrail shall be installed flush with the face of the bridge rail or parapet.

631.07 Traffic Barrier Terminal, Type 6. When attaching the end shoe to concrete, constructed with forms and with a thickness of 12 in. (300 mm) or less, the holes may be formed, core drilled, or an approved 3/4 in. (20 mm) cast-in-place insert may be used.

When attaching the end shoe to concrete, constructed with forms and with a thickness greater than 12 in. (300 mm), an approved 3/4 in. (M20) bolt with an approved expansion device may be used in lieu of core drilled or formed holes.

When attaching the end shoe to concrete constructed by slipforming, the holes shall be core drilled.

When no bridge approach curb is present, Type B concrete curb shall be constructed according to Section 606 and as shown on the plans.

631.08 Traffic Barrier Terminal, Type 6B. Attachment of the end shoe to concrete shall be according to Article 631.07, except the tapered, parapet, wood blackout will not be required.

631.09 Traffic Barrier Terminal, Type 8. The rail section on the turned down curb connector shall be a 25 ft (7.6 m) long section.

When a bridge expansion joint exists between the end shoe and the first post, all splice bolts and the end shoe and post bolts at the brackets shall be fitted with a lock nut or double nut and tightened only to a point that will allow guardrail movement.

631.10 Traffic Barrier Terminal, Type 10. If any portion of the existing name plate of the bridge will be covered by the end shoe, the name plate shall be moved to an adjacent area along the rail or end post before the end shoe is installed.

The standard end shoe shall be attached to the existing concrete with pre-drilled or self-drilling anchor bolts. The anchor cone shall be set flush with the surface of the concrete. Externally threaded studs protruding from the surface of the concrete will not be permitted. The standard end shoe shall be placed between the splice plate and the rail element.

The distance between any anchor and the edge of existing concrete shall be 6 in. (150 mm).

When a bridge expansion joint exists between the end shoe and the first post, all splice bolts at the end shoe shall be fitted with a lock nut or double nuts and tightened only to a point that will allow guardrail movement.

631.11 Shoulder Widening. When widening of existing shoulders is required for the construction of traffic barrier terminals, the earthwork shall be constructed as shown on the plans and according to Sections 202, 204, and 205.

631.12 Method of Measurement. The various types of traffic barrier terminals will be measured for payment, complete in place, in units of each. The pay limit between the traffic barrier terminal and the adjacent guardrail shall be as shown on the plans, except that it shall be at the centerline of the end shoe splice for traffic barrier terminal, Type 10.

Excavation in rock will be measured for payment according to Article 502.12.

Earthwork for shoulder widening will be measured for payment according to Article 202.07 and/or 204.07.

631.13 Basis of Payment. This work will be paid for at the contract unit price per each for TRAFFIC BARRIER TERMINAL, of the type specified.

The contract unit price per each for TRAFFIC BARRIER TERMINAL, TYPE 11, shall include any relocation of the traffic barrier terminal required in conjunction with the relocation of the temporary bridge rail.

Excavation in rock will be paid for according to Article 502.13.

Earthwork for shoulder widening will be paid for according to Article 202.08 and/or 204.08.

Terminal markers-direct applied for traffic barrier terminal Type 1, Special will be paid for separately.

Construction of Type B concrete curb for traffic barrier terminal, Type 6 will be paid for according to Article 606.15.

SECTION 632. GUARDRAIL AND CABLE ROAD GUARD REMOVAL

632.01 Description. This work shall consist of the removal and disposal of existing guardrail, including traffic barrier terminals, and cable road guard.

CONSTRUCTION REQUIREMENTS

632.02 General. The guardrail and cable road guard shall be removed so that all material considered suitable by the Engineer for future use shall be salvaged. Posts having salvage value shall be removed without damage and those having no salvage value shall be pulled, or cut off at least 6 in. (150 mm) below the ground surface. All holes shall be filled and tamped. The salvaged material shall be stored at locations and in a manner approved by the Engineer. Any of this material having salvage value and which has been damaged by the Contractor shall be replaced at his/her own expense with new material of the same kind.

632.03 Method of Measurement. This work will be measured for payment in feet (meters), measured from center to center of end posts.

632.04 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for GUARDRAIL REMOVAL or CABLE ROAD GUARD REMOVAL.

SECTION 633. REMOVING AND REERECTING GUARDRAIL AND TERMINALS

633.01 Description. This work shall consist of the complete removal and reerection of existing steel plate beam guardrail and traffic barrier terminals, or the rail elements of existing steel plate beam guardrail and traffic barrier terminals.

633.02 Materials. New materials, when required, shall be according to Articles 630.02 and 631.02.

CONSTRUCTION REQUIREMENTS

633.03 General. The removal, temporary storage, and reerection of existing guardrail and traffic barrier terminals shall be performed according to the applicable portions of Sections 630, 631 and 632.

New bolts, nuts and washers shall be used throughout in the reerection work. All existing C posts shall be replaced with new posts. Rail elements and posts that are damaged during removal or that are otherwise unsatisfactory for reerection shall be replaced.

Where existing steel blockouts are encountered, exclusive of Type C guardrail, they shall be replaced with either new wood or new plastic blockouts. The existing

Art. 633.03 Removing and Reerecting Guardrail and Terminals

steel posts may be drilled to match the bolt pattern shown on the plans for the wood block-out or a new steel post shall be provided.

Existing bolts shall be removed by removing or shearing the nuts. The use of a cutting torch to remove existing bolts will not be allowed.

When removal and reerection includes the rail element only, the guardrail shall be temporarily stored against the posts or at the shoulder line. The existing posts shall not be exposed overnight without rail elements.

The complete guardrail, guardrail elements, and traffic barrier terminals shall be reerected at the locations and according to the details shown on the plans.

633.04 Method of Measurement. The complete removal and reerection of the various types of steel plate beam guardrail will be measured for payment in feet (meters) in place at the location of reerection.

The complete removal and reerection of the various types of traffic barrier terminals will be measured for payment in place at the location of reerection in units of each according to Article 631.12.

The removal and reerection of the rail elements of steel plate beam guardrail and adjoining traffic barrier terminals will be measured for payment in feet (meters), measured from center to center of end posts.

Excavation in rock will be measured for payment according to Article 502.12.

633.05 Basis of Payment. The work of complete removal and reerection will be paid for at the contract unit price per foot (meter) for REMOVE AND REERECT STEEL PLATE BEAM GUARDRAIL, of the type specified, and at the contract unit price per each for REMOVE AND REERECT TRAFFIC BARRIER TERMINALS, of the type specified. Replacement of unsatisfactory rail elements and posts, except those damaged by the Contractor during removal, will be paid for according to Article 109.04.

The work of removal and reerection of rail elements only will be paid for at the contract unit price per foot (meter) for REMOVE AND REERECT RAIL ELEMENT OF EXISTING GUARDRAIL. Replacement of unsatisfactory rail elements, except those damaged by the Contractor during removal, will be paid for according to Article 109.04.

Excavation in rock will be paid for according to Article 502.13.

SECTION 634. GUARD POSTS

634.01 Description. This work shall consist of furnishing and setting guard posts.

634.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Guard Posts	1007.09
(b) Preservative Treatment	1007.12

CONSTRUCTION REQUIREMENTS

634.03 Preparation of Posts. The bottom of the posts shall be sawed square, and the tops shall be rounded to a hemisphere. This sawing and rounding shall be performed at the source of supply, and not in the field. All posts shall be peeled by removing all of the rough bark and at least 80 percent of the inner bark. All knots and projections shall be shaved smooth and flush with the surrounding wood.

634.04 Preservative Treatment. The posts shall be pressure treated after the sawing and rounding have been performed.

634.05 Setting Posts. The posts shall be set in compacted soil. The material in the bottom of the post holes shall be compacted to provide a stable foundation. The posts shall be set plumb with the front faces forming a smooth line. After the posts are in place, the holes shall be backfilled in layers with approved materials compacted in such a manner as not to displace the posts from correct alignment.

In lieu of setting posts in previously dug holes, the posts may be driven provided they are protected by a suitable driving cap, no damage is done to any portion of the post, they are driven plumb to the required depth and alignment with adequate lateral stability, and provided that the shoulders and adjacent slopes are not damaged from the driving operations. When, in the opinion of the Engineer, driving operations are producing unsatisfactory results, the posts shall be set in dug or bored holes.

634.06 Basis of Payment. This work will be paid for at the contract unit price per each for GUARD POSTS.

Excavation in rock will be measured and paid for according to Section 502.

SECTION 635. DELINEATORS

635.01 Description. This work shall consist of furnishing, installing, removing, and reinstalling delineator posts and reflectors.

635.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Metal Posts for Highway Markers, Signs and Delineators	1006.29
(b) Reflectors for Delineators	1097.03

CONSTRUCTION REQUIREMENTS

635.03 General. Delineators shall be spaced as shown on the plans. The spacing shall be carried across structures without interruption by means of bracket mountings fastened to the bridge rail. If the designated spacing causes a delineator location to occur at a pier of an overhead structure, the delineator may be omitted. When steel posts are used, they shall be unfinished.

635.04 Installing New Delineator Posts and Reflectors. Only one type of reflector and geometric shape will be permitted within the limits of a contract. The color of the reflectors shall be the same as the adjacent edge line.

For qualification purposes only, three samples required for tests shall be submitted by the Contractor. In addition, the Engineer will select three samples at random from each shipment for acceptance purposes.

Delineator reflectors shall be fastened to the posts with a vandal proof fastener approved by the Engineer.

The posts or brackets shall be vertical and oriented so that the face of the delineator shall be at 90 degrees to the centerline of the adjacent pavement.

Delineators shall be placed both as to lateral placement and height so as to have a satisfactory and uniform alignment. Acceptance of the delineator installation will include, in addition to ordinary inspection, a night inspection from an automobile by the Engineer and the Contractor, or a duly authorized representative. Delineators not having satisfactory and uniform night appearance shall be adjusted at the Contractor's expense until they do conform.

635.05 Removing and Reinstalling Existing Delineator Posts and Reflectors. Existing delineator posts and reflectors shall be removed and reinstalled at the locations and spacings shown on the plans.

Removal shall be performed in a manner that will not cause any damage to the existing posts or reflectors. Any posts or reflectors damaged during the removal shall be replaced by the Contractor with the same type at his/her own expense. When necessary, the existing posts and reflectors shall be stored within the right-of-way in a manner approved by the Engineer prior to reinstallation.

Reinstallation of the posts and reflectors shall be according to the applicable portions of Article 635.04. All damaged posts and reflectors shall be replaced with new posts and reflectors of the same type and color prior to reinstallation.

635.06 Method of Measurement. This work will be measured for payment in place in units of each.

635.07 Basis of Payment. The work of furnishing and installing new delineator posts and reflectors will be paid for at the contract unit price per each for DELINEATORS. No additional compensation will be allowed for two single reflector units placed back to back.

The work of removing and reinstalling existing delineator posts and reflectors will be paid for at the contract unit price per each for REMOVE AND REINSTALL DELINEATORS.

SECTION 636. CABLE ROAD GUARD

636.01 Description. This work shall consist of constructing a cable road guard consisting of a steel cable mounted on posts.

636.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Cables and Accessories for Cable Road Guard	1006.26
(b) Wood Posts and Wood Blockouts	1007.01, 1007.02, 1007.07
(c) Steel Posts	1006.23
(d) Preservative Treatment	1007.12
(e) Portland Cement Concrete (Note 1)	1020
(f) Reinforcement Bars	1006.10

Note 1. Concrete shall be Class SI concrete.

CONSTRUCTION REQUIREMENTS

636.03 General. Cable road guard shall be constructed at the locations and according to the details shown on the plans. Either wood or steel posts shall be used at the option of the Contractor. The posts shall be according to Article 630.05.

End anchor arrangements shall be constructed at the ends of cable road guard. Dead end anchor arrangement shall be used when cable road guard is placed adjacent to a bridge or when conditions will not permit placing the post anchor beyond the end post. When the length of the cable road guard is more than 500 ft (150 m), intermediate anchor arrangements shall be constructed at intervals not exceeding 500 ft (150 m).

Cable splices will be permitted provided that no single piece of unspliced cable is less than 50 ft (15 m). The cable shall be tensioned to the satisfaction of the Engineer.

636.04 Method of Measurement. Cable road guard will be measured for payment in feet (meters) in place from center to center of end posts.

636.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for CABLE ROAD GUARD, SINGLE STRAND.

SECTION 637. CONCRETE BARRIER

637.01 Description. This work shall consist of constructing a concrete barrier and its base.

637.02 Materials. Materials for the barrier and a portland cement concrete base shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Tie Bars	1006.10
(c) Dowel Bars	1006.11(b)
(d) Protective Coat	1023
(e) Nonshrink Grout	1024.02
(f) Chemical Adhesive Resin System	1027.01
(g) Preformed Expansion Joint Fillers	1051

Materials for a hot-mix asphalt (HMA) base shall be according to Section 1030.

637.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Hand Vibrator	1103.17(a)
(b) 10 ft (3 m) Straightedge	1103.17(h)

Equipment for a portland cement concrete base shall be according to Article 483.03.

Equipment for an HMA base shall be according to Article 356.03.

CONSTRUCTION REQUIREMENTS

637.04 Barrier Base. The base may be constructed separately or poured monolithically with the barrier. When constructed separately, a portland cement concrete base shall be constructed according to Articles 483.04 and 483.05, except the surface shall be finished according to Article 503.15(a). An HMA base shall be constructed according to Articles 356.04 through 356.06.

637.05 Anchoring. Barrier shall be anchored to the base by the methods shown on the plans. When tie bars are used, they shall be installed in preformed or drilled holes with a nonshrink grout or chemical adhesive.

637.06 Barrier Construction. Concrete barrier shall be constructed according to the applicable portions of Articles 503.06 and 503.07. Where the horizontal alignment of the concrete barrier is curved, the barrier shall be constructed either on the curved alignment or on cords, a maximum of 10 ft (3 m) in length.

When slipformed, the vertical centerline of the barrier shall not vary from the proposed centerline by more than 3 in. (75 mm) nor by more than 1/2 in. in 10 ft (13 mm in 3 m). All surfaces shall be checked with a 10 ft (3 m) straightedge as the concrete exits the slipform mold. Surface irregularities greater than 3/8 in. in 10 ft (10 mm in 3 m) shall be corrected immediately. Continued variations in the barrier surface exceeding 1/4 in. in 10 ft (6 mm in 3 m) will not be permitted and remedial action shall be taken immediately. Any deformations or bulges remaining after the initial set shall be removed by grinding after the concrete has hardened.

637.07 Barrier Transitions. Transitions between barriers of different design shall be constructed according to the details shown on the plans.

637.08 Joints. Joints shall be constructed as shown on the plans and as follows.

- (a) Construction Joints. Construction joints shall be constructed in the barrier whenever there is an interruption in the pour of more than 30 minutes.
- (b) Expansion Joints. Expansion joints shall be constructed in the barrier and the base in line with expansion joints in the adjacent pavement or shoulder. Expansion joints shall also be constructed at locations where the barrier abuts a rigid structure.

Prior to placing concrete, a light coating of oil shall be uniformly applied to the dowel bars.

- (c) Contraction Joints. Contraction joints shall be constructed in the barrier at uniform intervals with a maximum spacing of 20 ft (6 m) or in line with contraction joints in the adjacent pavement or shoulder. Contraction joints shall be formed by a groove 1/8 in. (3 mm) wide by 2 in. (50 mm) deep either formed in the plastic concrete or sawed after the concrete has set.

637.09 Finishing. The surface of concrete barrier shall be finished according to Article 503.15, except all holes and honeycombs shall be patched immediately.

637.10 Protective Coat. When required, protective coat shall be applied to the top and vertical surfaces of the barrier exposed to traffic. The protective coat shall be constructed according to Article 420.18.

637.11 Method of Measurement. This work will be measured as follows.

- (a) Contract Quantities. The requirements for the use of contract quantities shall be according to Article 202.07(a).
- (b) Measured Quantities. New barrier base, both separate and monolithic, will be measured for payment in feet (meters) in place, along the centerline of

the base or barrier. The width of the base will be defined as the width of the barrier.

Concrete barrier will be measured for payment in feet (meters) in place, along the centerline of the barrier.

Barrier transitions will be measured for payment in feet (meters) in place, along the centerline of the transition.

Protective coat will be measured for payment in place and the area computed in square yards (square meters).

637.12 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for CONCRETE BARRIER BASE; CONCRETE BARRIER, DOUBLE FACE, of the height specified; CONCRETE BARRIER, SINGLE FACE, of the height specified; and CONCRETE BARRIER TRANSITION.

When a double face concrete barrier with a variable cross-section is required, and the variation exceeds 3 in. (75 mm), the barrier will be paid for at the contract unit price per foot (meter) for CONCRETE BARRIER, VARIABLE CROSS-SECTION, of the height specified.

Protective coat will be paid for according to Article 420.20.

SECTION 638. GLARE SCREEN

638.01 Description. This work shall consist of constructing glare screens consisting of concrete glare screen, glare screen blades, or modular glare screen blades, mounted on concrete medians.

638.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Glare Screen Blades	1085
(b) Portland Cement Concrete (Note 1)	1020
(c) Reinforcement Bars	1006.10
(d) Modular Glare Screen Blades	1085
(e) Nonshrink Grout	1024.02
(f) Chemical Adhesive	1027

Note 1. Concrete shall be Class SI concrete.

CONSTRUCTION REQUIREMENTS

638.03 Glare Screen Blades. Glare screen blades and modular glare screen blades shall be installed on the concrete barrier according to the details shown on the plans. Base plate brackets or modules shall be placed true to line and at the spacing and angles shown on the plans. Anchor studs shall be at least 3 in. (75 mm) from any contraction, expansion, or construction joint in the barrier. Base plates shall be firmly attached to the concrete barrier with two expansion anchor studs. Modules

shall be firmly attached to the concrete barrier with six expansion anchor studs. Anchor studs shall be secured by tightening the nuts with 25 to 30 ft lb (34 to 40 N m) of torque.

The Contractor shall load test four percent of all anchor studs in the presence of the Engineer. The equipment and method used shall meet the approval of the Engineer. The minimum test load shall be 4000 lb (18 kN) in direct pull. For each anchor that fails the test requirement, two more anchor studs, picked by the Engineer, shall be tested. Each anchor stud that fails to meet the test requirement shall be reset, or removed and the hole drilled deeper and reset, and retested until it meets the test requirements.

Glare screen blades shall be placed on the base plate brackets true to line. When in final position, self-tapping screws shall be installed snug against the plastic surface without exceeding a maximum torque of 15 ft lb (20 N m).

Unless otherwise directed by the Engineer, all construction operations shall be performed on one side of the concrete median barrier. Any damage done to the concrete barrier by the Contractor's operation shall be repaired.

638.04 Concrete Glare Screen. Concrete glare screen shall be constructed according to the applicable portions of Section 637.

When concrete glare screen is constructed on an existing concrete barrier, the vertical reinforcement bars shall be anchored in place in drilled holes in the barrier with nonshrink grout or chemical adhesive. Joints in the concrete glare screen shall be a continuation of joints in the existing concrete barrier and shall be of the same configurations. In addition, if there is a crack in the barrier that is working as a joint, a joint shall be placed over it in the glare screen and the reinforcement shall be cut.

When concrete glare screen is constructed on new concrete barrier, it may be constructed integrally with the barrier. Joints in the glare screen shall be according to Article 637.08.

638.05 Method of Measurement. The various heights of glare screen blades will be measured for payment in units of each blade complete in place.

Concrete glare screen will be measured for payment in feet (meters) in place, along the centerline of the concrete glare screen.

Modular blade-type glare screen will be measured for payment in feet (meters) in place, along the centerline of the modular blade-type screen.

638.06 Basis of Payment. Glare screen blades will be paid for at the contract unit price per each for GLARE SCREEN BLADES, of the height specified.

Modular blade-type glare screens will be paid at the contract unit price per foot (meter) for MODULAR BLADE-TYPE GLARE SCREENS.

The work of constructing concrete glare screen will be paid for at the contract unit price per foot (meter) for CONCRETE GLARE SCREEN.

SECTION 639. PRECAST PRESTRESSED CONCRETE SIGHT SCREEN

639.01 Description. This work shall consist of furnishing and installing a precast prestressed concrete panel wall sight screen.

639.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Galvanized Steel Plates (Note 1)	1006.04
(b) Galvanized Bolts and Washers	1006.27(f)
(c) Prestressing Steel (Note 2)	1006.10(c)
(d) Coarse Aggregate	1004
(e) Portland Cement Concrete	1020

Note 1. Threaded inserts shall be galvanized steel capable of developing the shear strength of the bolts by which they are engaged and shall be approved by the Engineer.

Note 2. The steel shall be Grade 270, have a diameter of 3/8 in. (10 mm) and have a minimum cross sectional area of 0.085 sq in. (55 sq mm).

CONSTRUCTION REQUIREMENTS

639.03 General. The sight screen shall be as shown on the plans and according to AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, Traffic Signals, and AASHTO Standard Specifications for Highway Bridges. The earth upon which the base of each panel rests shall be firm and level for the entire width of the panel. Excavated material which is clean and free of organic content, or sand, may be used to even out deviations from the horizontal grade at the bottom of the excavation. The bottom of the excavation shall be compacted sufficiently to prevent unequal settlement of the panels as they are set in place.

639.04 Backfill. Backfill shall be coarse aggregate and shall be thoroughly compacted around the base of the wall using a mechanical tamper approved by the Engineer.

639.05 Lifting Devices. The type, number, and locations of lifting devices and the method of handling the precast prestressed panels shall be determined by the fabricator and approved by the Engineer. Portions of the lifting devices which project beyond the surface of the panel shall be sawed or burned off after erection. Lifting devices shall not be located in the surface of the panel facing toward the road.

639.06 Fabrication. The fabrication of the precast prestressed panels shall be according to the Manual for Fabrication of Precast Prestressed Concrete Products in effect on the date of invitation for bids.

639.07 Method of Measurement. The concrete wall will be measured for payment in feet (meters). The overall length will be measured along the longitudinal axis of the wall from the extreme ends of the end panels.

639.08 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for SIGHT SCREEN (PRECAST PRESTRESSED CONCRETE PANEL WALL), of the height specified.

SECTION 640. CHAIN LINK FENCE SIGHT SCREEN

640.01 Description. This work shall consist of furnishing and installing a chain link fence sight screen.

640.02 Materials. The steel posts shall be galvanized according to ASTM A 53. Structural steel tubing shall be according to ASTM A 501 and shall be galvanized according to AASHTO M 111. Fabric ties, fittings, bolts, nuts, and all other hardware shall be according to the applicable portions of Article 1006.27.

The top and middle brace rails shall be steel pipe 1 5/8 in. (41 mm) outside diameter, weight (mass) of 2.27 lb/ft (3.30 kg/m) and galvanized according to ASTM A 53.

Wood privacy slats shall be 5/16 or 3/8 in. x 2 3/8 in. (8 or 10 mm x 60 mm) and shall be factory installed. The slats shall be untreated redwood or cedar or treated timber of an approved alternate treated according to Article 1007.12. The slats shall be sound without decay or rot, containing no knot holes larger than one-half the width of the slat.

Steel chain link fabric shall be zinc-coated steel fabric or aluminum-coated steel fabric according to Article 1006.27. The fabric shall be #9 gauge (3.76 mm) wire woven in 3 1/2 x 5 in. (89 x 125 mm) mesh with the top and bottom selvages knuckled.

Zinc-coated or aluminum-coated metal slats of #26 gauge (0.5 mm) steel strip, 2 3/4 in. (70 mm) minimum width, shall be inserted into the chain link fabric, as shown on the plans, after the fabric is mounted against the posts. The zinc coating shall be according to ASTM A 653M coating designation Z275 (A 653 coating designation G90). The aluminum coating shall be according to ASTM A 463 coating designation TI 40. The coating on the slats shall be the same type as on the fabric.

Chain link fabric shall be attached to pull posts using minimum 1/4 x 3/4 in. (6 x 20 mm) flat stretcher bars and #12 gauge (2.69 mm) by 1 in. (25 mm) wide stretcher bar bands with 3/8 in. (10 mm) diameter carriage bolts. Stretcher bars, stretcher bar bands, and carriage bolts shall be according to Article 1006.27.

Tension cable shall be 3/8 in. (10 mm) diameter, 1 x 7 steel strand with 10,800 lb (48 kN) minimum breaking strength according to ASTM A 475 with Class B galvanized coating. Cable clamps and turnbuckles for use with tension cable shall be galvanized steel, be adequate to develop the full strength of the cable, and be approved by the Engineer.

Truss rods shall be 3/8 in. (10 mm) diameter and be provided with turnbuckles or some other suitable means of adjustment, and be according to Article 1006.26(b).

CONSTRUCTION REQUIREMENTS

640.03 General. The sight screen shall be as shown on the plans and according to AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

Pull posts shall be spaced as follows.

- (a) 240 ft (70 m) maximum centers for 6 ft (1.8 m) fence.
- (b) 200 ft (60 m) maximum centers for 8 ft (2.4 m) fence.
- (c) 160 ft (48 m) maximum centers for 10 ft (3.0 m) fence.

All posts shall be set in foundations of Class SI concrete of the depth and diameter shown on the plans.

Chain link fence construction shall be according to Section 664.

The chain link fabric shall be installed on the side of the posts facing toward the road, so the line posts and brace rails are hidden from the view of passing motorists.

640.04 Grounding. Continuous fence shall be grounded at intervals not exceeding 500 ft (150 m) in urban areas and 1,000 ft (300 m) in rural areas.

Fence under a power line shall be grounded by three grounds, one directly under the crossing and one on each side, 25 to 50 ft (7.5 to 15 m) away. A single ground shall be located directly under each telephone wire or cable crossing.

The ground wire shall be connected to the fabric and the ground rod by a mechanical clamp of a cast bronze body and bronze or stainless steel bolts and washers. The bottom connection of the ground wire shall be made to the tension cable.

640.05 Method of Measurement. Chain link fence sight screen will be measured for payment in feet (meters), along the top of the fence from center to center of the end posts.

640.06 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for SIGHT SCREEN (CHAIN LINK FENCE) of the height specified.

SECTION 641. WOOD FENCE SIGHT SCREEN

641.01 Description. This work shall consist of furnishing and installing wood fence sight screen.

641.02 Materials. Bolts and washers shall be according to Article 1006.17. Nails shall be galvanized common wire nails.

All lumber shall be sound and free from excessive splitting or deterioration. Dimensions shown on the plans are for surfaced (S4S) lumber. Rough sawn lumber of the nominal size shown may be used for any members provided it can be successfully stress graded and pieces of the same nominal size are sawn to a uniform width and thickness.

The required grade of lumber is visually stress graded according to the rules of the following agencies:

- (a) Douglas Fir & Western Red Cedar - West Coast Lumber Inspection Bureau
- (b) Southern Pine-Southern Pine Inspection Bureau
- (c) Red (Swamp) Cypress-National Hardwood Lumber Association

The grades shown below in the table are the minimum acceptable and all species shown are alternates for the indicated usage.

All wood, except Red (Swamp) Cypress and Western Red Cedar, used for posts, rails, or planks, shall be treated with ACA or CCA according to Article 1007.12, except the retention shall be specified in the following table.

Fence Height	Usage in. (mm)	Lumber Species	Commercial Grade	Preservative Retention	
				lb/cu ft	(kg/cu m)
6 ft (1.8 m) or 8 ft (2.4 m)	Rails 3 x 4 (75 x 100)	Douglas Fir Southern Pine	No. 2 No. 1/D	0.40 0.40	(6.41) (6.41)
	Posts 6 x 8 (150 x 200)	Douglas Fir	No. 2	0.60	(9.61)
	or 8 x 8 (200 x 200)	Southern Pine	No. 1/D	0.60	(9.61)
	Planks	Red (Swamp) Cypress Southern Pine Western Red Cedar	No. 2 No. 1/D No. 1 Fencing	0.40	NA (6.41) NA

CONSTRUCTION REQUIREMENTS

641.03 General. The sight screen shall be as shown on the plans and according to AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaire and Traffic Signals, AASHTO Standard Specifications for Highway Bridges. Wooden fence construction shall be according to the applicable portions of Section 507.

All fencing for any one installation shall be of the Wood Plank, Type P, or the Cedar Stockade, Type S. The two types shall not be mixed together.

Cedar pickets shall be either split or round, be completely stripped of bark, and be straight and free of excessive taper or bowing, and when installed, shall butt tightly against one another. There shall be no gaps greater than 1/4 in. (6 mm) in width between adjacent pickets.

Fence panels, consisting of horizontal rails and wood planks or cedar pickets, may be prefabricated or built in place. Additional nails, not shown on the plans, may be used to temporarily tack members in place during erection.

Nailing shall be done in such a manner as to avoid splitting the lumber. Lumber which, in the opinion of the Engineer, is split excessively, will be rejected.

641.04 Backfill. The backfill for posts shall be CA 6, CA 10, or CA 12 aggregate according to Article 1004.01. Backfill shall be thoroughly compacted, meeting the approval of the Engineer.

641.05 Method of Measurement. Wooden fence will be measured for payment in feet (meter), along the top of the fence from center to center of end posts.

641.06 Basis of Payment. This work will be paid for at the contract unit price per foot (meters) for SIGHT SCREEN (WOODEN FENCE), of the type and height specified.

SECTION 642. SHOULDER RUMBLE STRIPS

642.01 Description. This work shall consist of constructing rumble strips in shoulders.

642.02 Equipment. The equipment shall be a self-propelled milling machine with a rotary-type cutting head(s). The cutting head(s) shall be suspended from the machine such that it can align itself with the slope of the shoulder and any irregularities in the shoulder surface. The teeth of the cutting head(s) shall be arranged to provide a smooth cut, with no more than a 1/8 in. (3 mm) difference between peaks and valleys.

Prior to commencement of the work, the Contractor shall demonstrate the ability of the equipment to achieve the desired results without damaging the shoulder.

CONSTRUCTION REQUIREMENTS

642.03 General. The rumble strips shall be cut to the dimensions shown on the plans. Guides shall be used to ensure consistent alignment, spacing, and depth. In portland cement concrete shoulders, rumble strips may be formed according to the details shown on the plans immediately after the application of the final finish.

Rumble strips shall be omitted within the limits of structures, entrances, side roads, entrance ramps, and exit ramps. In portland cement concrete shoulders, rumble strips shall not be placed within 6 in. (150 mm) of transverse joints.

Cuttings resulting from this operation shall be disposed of according to Article 202.03 and the shoulders shall be swept clean.

642.04 Method of Measurement. This work will be measured for payment in feet (meters) along the edge of pavement. Measurement will include both the cut and uncut (formed and unformed) sections of the shoulder rumble strips with exceptions for bridge decks, approach pavements, turn lanes, entrances, and other sections where shoulder rumble strips have been omitted.

642.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for SHOULDER RUMBLE STRIPS.

OTHER ITEMS

SECTION 660. RESERVED

SECTION 661. HOT-MIX ASPHALT SHOULDER CURB

661.01 Description. This work shall consist of the construction of hot-mix asphalt (HMA) curb along the outer edge of HMA shoulders.

661.02 Materials. Materials shall be according to Article 406.02. The mixture composition shall be IL-9.5 or IL-9.5L.

CONSTRUCTION REQUIREMENTS

661.03 General. The temperature of the base on which the curb is placed shall not be less than 40 °F (4 °C) at the time the curb is placed. Prior to placing the curb, the base shall be cleaned and then primed with bituminous material at a rate of 0.05 to 0.1 gal/sq yd (0.2 to 0.5 L/sq m).

The HMA shoulder curb shall be constructed with a mechanical curb laying machine of a type approved by the Engineer. Prior to constructing the curb, additional shoulder shall be constructed according to the details shown on the plans. All exposed curb surfaces shall be sealed with a liberal application of any emulsified asphalt, asphalt binder, rapid curing liquid asphalt, or medium curing liquid asphalt listed in Section 1032. The material shall be applied uniformly by spraying or brushing at a rate satisfactory to the Engineer.

661.04 Method of Measurement. This work will be measured for payment in feet (meters) along the face of the curb in place. No deduction in length will be made for any drainage structures installed in the curbing.

The additional shoulder under the curb will not be measured for payment.

661.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for HOT-MIX ASPHALT SHOULDER CURB.

SECTION 662. CONCRETE SHOULDER CURB

662.01 Description. This work shall consist of the construction of concrete curb along the outer edge of portland cement concrete shoulders.

662.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Protective Coat	1023
(c) Poured Joint Sealers	1050

CONSTRUCTION REQUIREMENTS

662.03 General. Concrete shoulder curb shall be constructed according to the details shown on the plans and the applicable portions of Section 483. The concrete shoulder curb shall be constructed integrally with the portland cement concrete shoulder. Joints in the shoulder shall be continued through the curb and shall be sealed according to Article 420.12.

Protective coat shall be applied according to Article 420.18.

662.04 Method of Measurement. This work will be measured for payment in feet (meters) in place along the face of the curb. No deduction in length will be made, for any drainage structures installed in the curb.

Protective coat, if required, will not be measured for payment.

662.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for CONCRETE SHOULDER CURB.

SECTION 663. CALCIUM CHLORIDE APPLIED

663.01 Description. This work shall consist of furnishing and applying calcium chloride.

663.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Calcium Chloride	1013.01

CONSTRUCTION REQUIREMENTS

663.03 General. The rate of application per square yard (square meter) and the quantity shown in the contract is based on the amount of anhydrous chloride to be applied. The actual application rate shall be the rate shown in the contract divided by the decimal equivalent of the percent anhydrous chloride.

663.04 Method of Measurement. This work will be measured for payment by weight (mass) in tons (metric tons).

The quantity of calcium chloride for which payment will be made will be the total weight (mass) multiplied by the decimal equivalent of the percent of anhydrous chloride.

663.05 Basis of Payment. This work will be paid for at the contract unit price per ton (metric ton) for CALCIUM CHLORIDE APPLIED.

When it is specified that the calcium chloride is to be mixed with aggregate, the cost of mixing shall be included in the type of work performed.

SECTION 664. CHAIN LINK FENCE

664.01 Description. This work shall consist of constructing chain link fence, gates, and accessories.

664.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Chain Link Fabric	1006.27
(b) Line Posts (Steel Pipe, Structural Shapes and Roll Formed Sections)	1006.27
(c) Terminal Posts (End, Corner or Pull)	1006.27
(d) Gate Posts	1006.27
(e) Tension Wire	1006.27
(f) Horizontal Braces	1006.27
(g) Truss Rods	1006.26
(h) Gate Frames	1006.27
(i) Post Tops	1006.28
(j) Stretcher Bars (Note 1)	1006.27
(k) Fabric Ties	1006.27
(l) Fittings	1006.27
(m) Bolts and Nuts	1006.27
(n) Barbed Wire	1006.28
(o) Portland Cement Concrete (Note 2)	1020

Note 1. Stretcher bars shall be galvanized flat steel bar not less than 1/4 x 3/4 in. (6 x 19 mm) and the stretcher bar bands shall be galvanized flat steel bar not less than 1/8 x 1 in. (3 x 25 mm) with an 3/8 in. (M10) galvanized carriage bolt.

Note 2. Class SI concrete shall be used. When concrete is mixed in truck mixers or transported in agitating trucks, the time limit for unloading it may be extended to 120 minutes when approved by the Engineer.

CONSTRUCTION REQUIREMENTS

664.03 General. Prior to constructing the fence, the area along the line of the fence shall be cleared according to Section 201.

At locations of small natural or drainage ditches where it is not practical to conform the fence to the general contour of the ground surface, the Contractor, when directed, shall span the opening below the fence with barbed wire fastened to stakes of such length as required. The new fence shall be permanently tied to the terminals of existing fences whenever required by the Engineer. The finished fence shall be plumb, taut, true to line and ground contour, and complete in every detail. Where directed, the Contractor will be required to stake down the chain link fence at several points between posts.

664.04 Installing Posts. Posts shall be properly spaced and set in concrete. Wherever right-of-way markers are omitted, the posts shall be set with back of post flush with the right-of-way line.

On terminal (end, corner, pull, brace) and gate posts, the post tops where required and brace rail clamps around the posts shall be placed before setting the posts in concrete bases. In setting the gate posts, great care shall be taken to make sure that gate posts are set the exact distance apart as shown on the plans. A line drawn across from the top of one gate post to the other shall be level, regardless of the grade at the ground line. If the ground is not level, the upgrade post shall be set first to get the proper height for the downgrade post. Fence shall not be erected until the concrete encasement around the posts has cured for at least seven days. Stretcher bar bands and truss bands as called for on the plans shall be spread and slipped on end, corner, pull, brace, and gate posts as the next operation. Post tops shall then be installed on all other posts where required.

664.05 Post Tops. All hollow pipe and tube type posts shall be fitted with post tops. The bases of the post tops shall have flanges which fit around the outside of the posts and shall be secured in place.

664.06 Tension Wire. Tension wires shall be used in the erection of chain link fence. The top and bottom tension wire shall be placed, stretched taut, and secured at ends to all posts in a satisfactory manner before fabric is placed. Tension wire shall be stretched tight with galvanized turn buckles spaced at intervals of not more than 1000 ft (300 m).

664.07 Braces. When required by the plans, braces shall be placed 12 in. (300 mm) down from the top of the terminal posts and shall extend from the terminal (end, corner and pull) posts and gate posts to the brace posts. The braces shall be securely fastened to the post and trussed from brace post back to terminal posts with 3/8 in. (10 mm) round rods with a turnbuckle.

664.08 Fabric. The fabric shall be unrolled on the outside of the fence line with the bottom edge of the fabric against the posts. The various rolls shall be spliced by bringing the ends close together and weaving in a picket in such a way that it will engage both of the roll ends and catch with each twist each separate mesh of the end pickets of both rolls of fabric.

At end, corner or gate posts, the stretcher bar shall be slipped through the end picket of the fabric and the stretcher bar bands at the same time. Then the bolts in the stretcher bar bands shall be tightened. Additional rolls of fabric shall be spliced and placed as the erection progresses along the fence. In long sections, the fence shall be stretched at intervals of about 100 ft (30 m). The fabric shall be placed by securing one end and applying sufficient tension to remove all slack before making attachments elsewhere. After the fabric has been stretched, it shall be tied to the tension wire with fabric ties spaced not more than 24 in. (600 mm) apart. The fabric shall then be attached to the line posts with fabric ties spaced not more than 14 in. (355 mm) apart. The topmost clip shall be placed on the line post as near the top of the fabric as possible and the lowest clip as near the bottom of the fabric as possible. At terminal (end, corner and pull) and gate posts, the fabric shall be fastened with stretcher bars and bands. The fasteners shall be spaced not more than 14 in. (355 mm) on centers for terminal (end, corner and pull) and gate posts. The topmost band shall be placed on these posts as near the top of the fabric as possible and the lowest band as near the bottom as possible.

Standard chain link fence stretching equipment shall be provided for stretching the fabric before tying it to the tension wire and posts. The stretching and tying operations shall be repeated about every 100 ft (30 m) until the run of fence is completed.

Before making a closure, the other end of the run shall be fastened to the end, corner or gate post as described previously. The operation of making a closure of a run shall be as follows: The stretching equipment shall be clamped on the ends of the fabric parallel to each other and about 5 ft (1.5 m) apart when the tension is first applied. The stretching shall continue until the slack has been removed from both sections of the fabric. If the ends overlap, the fabric shall be cut to match. The ends shall be joined by the insertion of a picket similar to the methods of connecting two rolls of fabric.

664.09 Gates. The gates shall be hung on gate fittings as shown on the plans. The lower hinge (ball and socket type) shall be placed on top of the concrete in which the gate post is set. The sockets for the cane or foot bolts shall be set in concrete so that the plunger pin will fit perfectly in the socket when the gate is in a closed position. Gates shall be so erected as to swing in the direction indicated and shall be provided with gate stops as specified or shown on the plans. Gate keepers shall be provided to hold gates when in open position, and shall be located and installed as directed by the Engineer. Gates shall be erected in suitable places as shown on the plans. All hardware shall be thoroughly secured, properly adjusted and left in perfect working order. Hinges and diagonal bracing in gates shall be adjusted so that gates will hang level.

664.10 Existing Fence Connections. Wherever a new fence joins an existing fence, either at a corner or at the intersection of straight line fences, a corner

post with brace post shall be set at the junction and braced the same as described for corner posts or as shown on the plans.

If the connection is made at other than the corner of the new fence, the last span of the old fence shall contain a brace span.

664.11 Protective Electrical Ground. Continuous fence shall be grounded at intervals not exceeding 500 ft (150 m) in urban areas and 1000 ft (300 m) in rural areas. There shall be a ground within 100 ft (30 m) of gates in each section of the fence adjacent to the gate.

Fence under a power line shall be grounded by three grounds, one directly under the crossing and one on each side 25 to 50 ft (7.5 to 15.0 m) away. A single ground shall be located directly under each telephone wire or cable crossing.

The counterpoise ground shall be used only where it is impossible to drive a ground rod.

The ground wire shall be connected to the fabric and the ground rod by a mechanical clamp of cast bronze body and bronze or stainless steel bolts and washers.

664.12 Method of Measurement. Chain link fence will be measured for payment in feet (meters), along the top of the fence from center to center of end posts, excluding the length occupied by gates.

Excavation in rock will be measured for payment according to Article 502.12.

664.13 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for CHAIN LINK FENCE, of the height specified, and at the contract unit price per each for CHAIN LINK GATES, of the opening sizes and types specified.

Excavation in rock will be paid for according to Article 502.13.

SECTION 665. WOVEN WIRE FENCE

665.01 Description. This work shall consist of constructing a combination woven wire and barbed wire fence, gates, and accessories.

665.02 Materials. Materials shall be according the following.

Item	Article/Section
(a) Woven Wire Fencing	1006.28
(b) Barbed Wire	1006.28
(c) Wood Posts	1007.01, 1007.02, 1007.11
(d) Wood Braces and Blocks	1007.01, 1007.02, 1007.11
(e) Preservative Treatment	1007.12
(f) Brace Wires	1006.28
(g) Metal Posts	1006.28
(h) Metal Braces	1006.28
(i) Gate Frames	1006.28

(j) Fittings and Miscellaneous Materials	1006.28
(k) Bolts and Nuts	1006.27
(l) Portland Cement Concrete (Note 1)	1020

Note 1. Class SI concrete shall be used. When concrete is mixed in truck mixers or transported in agitating trucks, the time limit for unloading it may be extended to 120 minutes when approved by the Engineer.

CONSTRUCTION REQUIREMENTS

665.03 General. Prior to constructing the fence, the area along the line of the fence shall be cleared according to Section 201.

Posts shall be set vertical and in true alignment. The new fence shall be permanently tied to the terminals of existing fences when required by the Engineer.

Metal corner, end, pull posts, and braces shall be properly spaced and set in concrete. Metal line posts may be driven in place.

All wood posts shall be set according to Article 634.05.

Any high points which interfere with the placing of woven wire shall be graded to provide the clearance shown on the plans.

Barbed and woven wire shall be pulled tight, according to standard practice and the recommendations of the manufacturer, and shall be fastened to wood posts by means of 1 1/2 in. (40 mm) minimum galvanized fence staples and to metal posts by means of wire, clips or other suitable fasteners. Splicing barbed or woven wire shall be accomplished by using either a wrapped splice or a corrosive resistant, compressed sleeve type splice meeting the approval of the Engineer. When a wrapped splice is used for woven wire, the vertical wires adjacent to the ends shall be brought together and the end of each horizontal wire wrapped not less than six complete turns around the other corresponding horizontal wire. When barbed wire is spliced, each end shall be wrapped not less than six complete turns around the other wire.

Gates shall be assembled and installed according to the details shown on the plans. Vehicle gates shall swing open 180 degrees. Pedestrian gates shall swing open 90 degrees. Gate keepers shall be provided to hold gates when in an open position and shall be located and installed as directed by the Engineer.

Continuous fence shall be grounded at intervals not exceeding 200 ft (60 m). There shall be a ground not exceeding 35 ft (10.7 m) from a gate in each section of the fence adjacent to a gate. There shall be a minimum of one ground in any partial section of fence, constructed separately but in conjunction with main fence.

Fence under a power line shall be grounded by three grounds, one directly under the crossing and one on each side 25 to 35 ft (8 to 10.7 m) away. A single ground shall be placed directly under each telephone wire or cable crossing. Each barbed wire and the top and bottom wires of the woven fence shall be fastened to the metal post by a mechanical means to assure a tight connection for positive grounding.

Art. 665.03

Woven Wire Fence

When metal line posts are used in lieu of wood line posts, this grounding is not required.

665.04 Method of Measurement. Woven wire fence will be measured for payment in feet (meters) along the top of the fence from center to center of end posts, excluding the length occupied by gates.

Excavation in rock will be measured for payment according to Article 502.12.

665.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for WOVEN WIRE FENCE, and at the contract unit price per each for WOVEN WIRE GATES, of the sizes and types specified.

Excavation in rock will be paid for according to Article 502.13.

SECTION 666. RIGHT-OF-WAY MARKERS

666.01 Description. This work shall consist of furnishing and erecting concrete right-of-way markers, or removing and reerecting right-of-way markers.

666.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Precast Concrete Right-of-Way Markers	1042
(b) Reinforcement Bars	1006.10

CONSTRUCTION REQUIREMENTS

666.03 Furnishing and Erecting. Right-of-way markers shall not be erected within the corporate limits of cities, villages or towns. When erected within improved residential areas, Method B right-of-way markers shall be used. Method A right-of-way markers shall be used at all other locations as shown on the plans.

Right-of-way markers shall be set so the back of the post is flush with the right-of-way line, except when the marker conflicts with a property pin, in which case the right-of-way marker shall be offset. The markers shall be set in compacted soil, and the bottom of the holes shall be rammed to provide a stable foundation. They shall be set in a vertical position with the lettered side facing the roadbed. The holes shall be backfilled and thoroughly compacted with approved materials in layers in such manner that the bottom of the markers will remain in the correct position.

Right-of-way markers shall be erected before any grading operations are started, except that markers in easement areas may be erected after the final grading is complete.

666.04 Removing and Reerecting. Existing right-of-way markers designated to be removed and reerected shall be removed in a manner that will not damage the marker. Any marker damaged during removal shall be replaced with a new marker. Holes shall be backfilled as directed by the Engineer.

The existing right-of-way markers shall be reerected at the locations shown on the plans. Reerecting of existing right-of-way markers shall be according to Article 666.03. Existing markers damaged during removal or otherwise considered unsatisfactory for reuse shall be replaced with new markers before reerecting.

666.05 Basis of Payment. Furnishing and erecting right-of-way markers will be paid for at the contract unit price per each for FURNISHING AND ERECTING RIGHT OF WAY MARKERS.

Removing and reerecting existing right-of-way markers will be paid for at the contract unit price per each for REERECTING RIGHT OF WAY MARKERS. Replacement of unsatisfactory right-of-way markers, except those damaged by the Contractor during removal, will be paid for according to Article 109.04.

Excavation in rock will be measured and paid for according to Section 502.

SECTION 667. DRAINAGE MARKERS AND PERMANENT SURVEY MARKERS

667.01 Description. This work shall consist of furnishing and erecting drainage markers or furnishing and installing permanent survey markers.

667.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Reinforcement Bars	1006.10
(c) Precast Concrete Drainage Markers	1042
(d) Precast Concrete Survey Markers	1042

CONSTRUCTION REQUIREMENTS

667.03 Drainage Markers. Drainage markers shall be placed at the right-of-way line at the locations shown on the plans. They shall be erected according to Article 666.03. The reference in Article 666.03 to right-of-way markers shall be construed to include drainage markers.

667.04 Permanent Survey Markers. Except where it is necessary to install the bronze tablet in an existing rock ledge, concrete pavement, or a structure, the markers shall be either precast or cast in place at the option of the Contractor. Class SI concrete shall be used throughout.

The location of the markers shall be according to the plans. The markers shall be placed at the P.T.'s and P.C.'s of horizontal curves and spaced along the tangents such that a minimum of two markers are always inter-visible.

The markers shall be placed under the direction of the Engineer and shall be installed in such a manner that there will be no future settlement or horizontal shifting. The monuments shall be placed in a way that the survey point will fall within the portion of the tablet provided for that purpose.

The project designation, the centerline station, the survey point, and the elevation shall be permanently marked on the tablet by the use of metal dies after the marker has been installed.

667.05 Basis of Payment. The work of furnishing and erecting drainage markers will be paid for at the contract unit price per each for FURNISHING AND ERECTING DRAINAGE MARKERS.

The work of furnishing and installing permanent survey markers will be paid for at the contract unit price per each for PERMANENT SURVEY MARKERS, of the type specified.

Excavation in rock will be measured and paid for according to Section 502.

SECTION 668. PRESERVATION OF STONES AND OTHER MARKERS

668.01 Description. This work shall consist of preserving section or subsection stones and other markers.

CONSTRUCTION REQUIREMENTS

668.02 General. All stones and other markers encountered in the field shall be cross-tied prior to construction operations. This work shall be done by an Illinois Professional Land Surveyor. The Illinois Professional Land Surveyor shall reference the exact location of the existing monument, supervise the resetting of the monument, and prepare a monument record. The new monument record shall be filed in the County Recorder of Deeds at the County Court House in the County involved and a copy of the filed monument record shall be supplied to the District Chief of Surveys.

668.03 Basis of Payment. This work will be paid for according to Article 109.04.

SECTION 669. REMOVAL AND DISPOSAL OF REGULATED SUBSTANCES

669.01 Description. This work shall consist of the excavation, removal, and proper disposal of contaminated soil, water, and underground storage tanks (UST), their content and associated underground piping to the point where the piping is above the ground, including determining the content types and estimated quantities.

669.02 Equipment. All equipment shall comply with OSHA and API guidelines. Decontamination shall be performed on all equipment as appropriate to the regulated substance and degree of contamination according to OSHA and API guidelines. All cleaning fluids used to decontaminate the tank and/or equipment shall be treated as the contaminant unless laboratory testing proves otherwise.

The Contractor shall furnish, in a clean condition, all equipment used for purposes of excavation, temporary storage, and transportation of material classified as non-special waste, non-hazardous special waste, or hazardous waste. Clean condition means the equipment does not contain any residual material classified as a

non-special waste, non-hazardous special waste, or hazardous waste. Residual materials include, but are not limited to, petroleum products, chemical products, sludges, or any other material present in or on equipment.

The Contractor shall notify the Engineer of the delivery of all excavation, storage, and transportation equipment to a work area location. Before beginning any associated soils management activity, the Contractor shall provide the Engineer with the opportunity to inspect the equipment. The Engineer shall approve the use of the equipment at the time of the visual inspection. The Engineer shall require the equipment to be decontaminated, if the equipment contains contaminated residual material.

669.03 Qualifications. The Contractor or subcontractor shall be a qualified environmental firm approved by the Engineer and District Environmental Coordinator. If the project includes an underground storage tank, the Contractor or subcontractor shall be licensed and certified with the Office of the State Fire Marshall (OSFM) and shall possess all permits required to perform the work described in the plans and specifications.

669.04 Contractor Requirements. The Contractor shall file a written Site Contamination Operation Plan, Site Health and Safety Plan, and Erosion Control Plan applicable for all personnel working on the project. The Site Health and Safety Plan shall pertain to any visitors or State employees at the site. The Contractor shall submit monthly or quarterly reports and a final technical report to the Engineer.

The Contractor shall provide a State certified manifest to the Engineer for the transport and disposal of all non-hazardous special waste (hereafter referred to as special waste) or hazardous waste and the removed UST.

The Contractor shall contact the local OSFM's office in writing at least 30 days prior to starting the excavation to remove any UST(s). The Contractor shall also contact the Engineer and the local OSFM's office at least 72 hours prior to removal to confirm the OSFM inspector's presence during the UST removal. Removal, transport, and disposal of the UST shall be according to the applicable portions of the latest revision of the "American Petroleum Institute (API) Recommended Practice 1604".

CONSTRUCTION REQUIREMENTS

669.05 Site Contamination Operation Plan. The Contractor shall develop a project specific Site Contamination Operation Plan and submit the plan to the Engineer a minimum of two weeks before beginning construction activities. The plan shall outline the procedures used to mobilize all required subcontractors in a timely fashion, and provisions to continue work in areas determined to be contaminated. The plan shall also meet all requirements for the removal and disposal of non-special waste, special waste, or hazardous waste.

The Site Contamination Operation Plan shall provide a list of all proposed subcontractors, indicating the service each is to provide. The Contractor and subcontractors shall provide a Statement of Qualifications demonstrating their capabilities to provide services as indicated in the Site Contamination Operation Plan.

669.06 Site Health and Safety Plan. The Contractor shall develop a project specific Health and Safety Plan and submit the plan to the Engineer a minimum of two weeks before beginning construction activities.

The plan shall specify procedures and equipment to protect site workers and observers from hazards encountered during activities in locations containing contaminated material. A qualified industrial hygienist or health and safety specialist shall prepare the Health and Safety Plan. The Contractor's Corporate Officer responsible for worker health and safety shall approve and sign the plan before submittal to the Department.

A qualified industrial hygienist is defined as having a minimum of five years of experience in the industrial hygiene field, an academic degree in a related science field, and successful completion of two days of testing presented by the American Board of Industrial Hygiene. A Certified Industrial Hygienist (CIH) meets the above definition.

A qualified Health and Safety Specialist is defined as having a minimum of three years experience in hazardous waste operations, familiar with applicable health and safety procedures and protocols, and holds current training status according to 29 CFR 1910.120. This person may be a Certified Safety Professional (CSP) or an Illinois Registered Professional Engineer. A CSP has a minimum of four years of professional safety experience, has a baccalaureate degree in safety, and has successfully completed the Safety Fundamentals examination and subsequent Specialty Examination presented by the Board of Certified Safety Professionals.

The Contractor's Corporate Officer responsible for the Contractor's health and safety program and approval of the Health and Safety Plan shall be able to identify hazards; assess employee exposure and risk; have knowledge of OSHA standards, hazards correction techniques and practices, work place safety, and health program requirements. This person shall also be able to effectively communicate this knowledge both orally and in writing or contract for these abilities with a qualified Industrial Hygienist or Health and Safety Specialist.

The responsibility for the implementation and enforcement of all health and safety requirements lies solely with the Contractor. The Contractor shall take all necessary precautions for the safety of, and provide the necessary protection to prevent damage, injury or loss to construction personnel performing work within the Exclusion and Decontamination Zones. The Contractor shall ensure all workers involved in any activities within the contaminated locations or associated with the contaminated materials are conversant with all the requirements of the Health and Safety Plan and have signed off and dated personal acknowledgment of the plan. The Contractor shall post copies of the plan at various locations throughout the work area to facilitate spontaneous review.

Any delays in work start-up or down time that are the result of Contractor time requirements for performing amendments to the Health and Safety Plan or Contractor inability to comply with EPA and/or OSHA safety and health regulations will not be compensated by the Department if the Department determines the Contractor did not adhere to the requirements as stated in these specifications.

- (a) Zones. Three distinct zones (exclusion, decontamination, and support) shall divide the affected portions of the project.
- (1) Exclusion Zones are the areas where contamination does or could occur. These zones have the highest inhalation exposure potential and/or a high probability of skin contact with potential contaminants/contaminated material. The Exclusion Zone designation shall remain until the entire excavated area has been completely backfilled. The Contractor shall ensure that neither their employees nor subcontractors execute maintenance nor repair operations on equipment located in the Exclusion Zone.
 - (2) Decontamination Zones are areas established to prevent the transfer of contaminants outside the Exclusion Zones. This zone eliminates the possibility of the physical transfer of contaminating substances on people, equipment, or in the air to unregulated areas. A combination of decontamination, distance from active work areas, zone restrictions, and work function shall eliminate the possibility of physical transfer of contamination. This zone has the next highest inhalation hazard, but does not pose a high probability of skin contact. This zone shall contain the equipment decontamination facility, and areas designated for personnel decontamination, and emergency equipment.
 - (3) Support zones shall include the remaining areas of the job site. This zone shall contain the change and shower rooms, lunch and break areas, operation direction, and support facilities (including supplies, equipment storage, and maintenance areas). No equipment or personnel shall enter the Support Zone from the Exclusion Zone without passing through the personnel or equipment Decontamination Zone. Eating, smoking, etc., shall be allowed only in this zone.

The Contractor shall ensure each worker has the proper personal protective equipment for the zone and location in which he/she is to perform construction or materials management activities. The Contractor shall be responsible for providing all personal protective equipment required by the Department and Contractor personnel. The Contractor shall define the provisions for personal protective equipment in the Site Health and Safety Plan.

The Contractor through the Site Health and Safety Plan shall determine the appropriate level of protection. The Contractor shall ensure the appropriate protective equipment is being used during activities in the Exclusion Zone and Decontamination Zone. The Contractor shall notify the Engineer of any variations from the defined levels of protection as stipulated in the Contractor's Health and Safety Plan in writing before implementation of the modifications.

- (b) Decontamination. All personnel shall go through decontamination who have participated in construction or soil management activities within the Exclusion Zone. In addition, the Contractor shall perform a wet and/or dry decontamination process on excavation and construction equipment as

specified when equipment is in contact with contaminated material. No equipment or vehicle shall track visible material from a contaminated facility.

- (1) **Personnel Decontamination.** All outer protective clothing used by personnel who contact contaminated material while in the Exclusion Zone shall be collected in plastic bags and placed in leak-proof sealable containers, such as 55 gal (208 L) open-top drums. The Contractor shall transport all containers to a secure staging area for temporary storage. The Contractor shall inform the Engineer of the time and manner of disposal of containers containing contaminated protective clothing. The Contractor shall be responsible for transporting and disposing of the containers. The Contractor shall be responsible for ensuring the personnel decontamination portion of this zone contains clean, unused 6 mil (150 micron) polyethylene sheeting.
- (2) **Equipment Decontamination.**
 - a. **Dry Decontamination.** The Contractor shall perform dry decontamination on equipment that has contacted material classified as a non-special waste, special waste, or hazardous waste before moving that equipment to any other location, whether the new location is contaminated or uncontaminated. Dry equipment decontamination shall consist of the removal of all visible material from excavation and construction equipment parts, such as shovels, wheel tracks, and buckets. During dry decontamination, the Contractor shall ensure that removed contaminated material does not contact the ground surface. The Contractor shall place all contaminated material removed during dry decontamination with contaminated material of similar classification and dispose of with other excavated material from that facility location.
 - b. **Wet Decontamination.** The Contractor shall perform the wet decontamination process when construction/soil management activities associated with non-special waste, special waste, or hazardous waste are followed by construction/soil management activities associated with uncontaminated excavation or fill material. If the Engineer observes residual and/or nonspecial waste, special waste, or hazardous waste material during the initial (or subsequent) inspection of equipment, the Engineer will require the Contractor to perform either wet and/or dry decontamination before approving equipment for use at another location. Before departure from the project area, all equipment and vehicles contacting contaminated material shall be wet decontaminated by the Contractor.

Personnel shall perform all wet equipment decontamination within the Decontamination Zone on equipment decontamination pad(s). The Contractor shall be responsible for the construction and maintenance of the decontamination pad(s) and for all equipment, materials, and personnel. The pad(s) shall be designed to prevent loss of decontamination liquids to the surrounding environment

through vertical infiltration and/or surface runoff from any part of the pad(s).

The Contractor shall place all removed wastes from the decontamination pad(s) in leak-proof containers and store temporarily in a secure staging area. The Contractor shall containerize the solids separate from the liquids. The Contractor shall be responsible for the transport and disposal of all waste generated from the decontamination process.

- (c) Medical Exams. The Contractor shall certify that all personnel in his/her work force who shall be working in an Exclusion or Decontamination area, have received and passed a current medical examination as required under applicable federal, state and/or local standards.
- (d) Health and Safety Training. The Contractor shall certify that all personnel within his/her work force who shall be working within an Exclusion or Decontamination area successfully complete a 40-hour Health and Safety Training Course pursuant to applicable federal, state and/or local standards, including OSHA requirements under 29 CFR 1910.120. All Contractor supervisors and craft foremen shall have successfully completed an additional eight hour Supervisor Training Course pursuant to applicable federal, state and/or local standards, including OSHA requirements under 29 CFR 1910.120.

669.07 Site Contamination Erosion Control Plan. The Contractor shall prevent stormwater from Support Zones from running into excavated contaminated areas. The Contractor shall divert all stormwater away from the Exclusion and Decontamination areas using appropriate stormwater and erosion control methods. Failure to use appropriate measures to divert stormwater will subject the Contractor to removing and properly containing the water at their own expense. The Contractor shall provide pumps and collect standing water from the excavation before continuing removal activities or other construction activities. The Contractor shall collect the removed water, place it in leak-proof storage containers, and store it in a secure staging area for future testing by the Contractor. The Contractor shall ensure the storage containers have access points to facilitate sampling. The Contractor shall inform the Engineer concerning management and disposal requirements for the water following the evaluation of the analytical results.

The Contractor shall control and minimize the release of dust during non-special waste, special waste, or hazardous waste removal activities. The Contractor may use water or acceptable chemicals to control dust emissions. The Contractor shall submit, in writing or include within the Site Contamination Operation Plan, a description of intended dust control measures to the Department for approval at least two weeks before commencement of soil excavation/construction activities.

669.08 Contaminated Soil and/or Groundwater Monitoring. The Contractor shall hire a qualified environmental firm to monitor the area containing the regulated substances. The affected area shall be monitored with a PID or FID field screen. A field screen reading of more than ten meter units (non-methane) above background indicates the potential presence of contaminated material requiring handling as a non-special waste, special waste, or hazardous waste. The PID or FID

meter shall be calibrated on site and background level readings taken and recorded daily. All testing shall be done by a qualified engineer/technician. Such testing and monitoring shall be included in the work. The Contractor shall identify the exact limits of removal of non-special waste, special waste, or hazardous waste. All limits shall be approved by the Engineer prior to excavation. The Contractor shall take all necessary precautions.

Based upon PID or FID readings indicating contamination, a soil or groundwater sample shall be taken from the same location and submitted to an approved laboratory. Soil or groundwater samples shall be analyzed for the contaminants of concern based on the property's land use history. The analytical results shall serve to document the level of soil contamination. When the analytical results indicate detected levels are at or below the most stringent Tier 1 Soil Remediation Objectives for Residential Properties presented in Appendix B Table A of 35 Illinois Administrative Code 742 (IAC), the soil excavated shall be included in the storm sewer or earth excavation, as appropriate, and backfill shall be according to Section 205 and/or 208. When the analytical results indicate detected levels are above the most stringent Tier 1 Soil Remediation Objectives for Residential Properties presented in Appendix B, Table A of 35 IAC 742, the soil excavated shall be considered a waste and managed as stated. When groundwater analytical results indicate the detected levels are above Appendix B, Table E of 35 IAC 742, the most stringent Tier 1 Groundwater Remediation Objectives for Groundwater Component of the Groundwater Ingestion Route for Class 1 groundwater, the groundwater shall be managed off-site as a special waste. Soil and groundwater samples may be required at the discretion of the Engineer to verify the level of soil and groundwater contamination.

Samples shall be grab samples (not combined with other locations). The samples shall be taken with disposable instruments. The samples shall be placed in sealed containers and transported in an insulated container to the laboratory. The container shall maintain a temperature of 39 °F (4 °C). All samples shall be clearly labeled. The labels shall indicate the sample number, date sampled, location and elevation, and any other observations.

The laboratory shall use a detectable concentration which is equal to the lowest appropriate practical quantitation limits (PQL) or estimated quantitation limit (EQL) specified in "Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods", EPA Publication No. SW-846 and "Methods for the Determination of Organic Compounds in Drinking Water", EPA, EMSL, EPA-600/4-88/039. For parameters where the specified cleanup objective is below the acceptable detection limit (ADL), the ADL shall serve as the cleanup objective. For other parameters the ADL shall be equal to or below the specified cleanup objective.

669.09 Contaminated Soil and/or Groundwater Management and Disposal. Soil and/or concrete removed from an excavation which is determined by the Engineer to be contaminated, will not be placed in the excavation. All groundwater encountered within lateral trenches may be managed within the trench and allowed to infiltrate back into the ground. If the groundwater cannot be managed within the trench it must be removed as a special or hazardous waste. The Contractor is prohibited from managing groundwater within the trench by discharging it through any existing or new storm sewer. The Contractor shall install backfill plug within the area of groundwater contamination.

One backfill plug shall be placed down gradient to the area of groundwater contamination. Backfill plugs shall be installed at intervals not to exceed 50 ft (15 m). Backfill plugs are to be 4 ft (1.2 m) long, measured parallel to the trench, full trench width and depth. Backfill plugs shall not have any fine aggregate bedding or backfill, but shall be entirely cohesive soil or any class of concrete. The Contractor shall provide test data that the material has a permeability of less than 10^{-7} cm/sec according to ASTM D 5084, Method A or per another test method approved by the Engineer.

The Contractor shall use due care when transferring contaminated material from the area of origin to the transporter. Should releases of contaminated material to the environment occur that are visible (i.e., spillage onto the ground, etc.), the Contractor shall clean-up spilled material and place in the appropriate storage containers as previously specified. Clean-up shall include, but not be limited to, sampling beneath the material staging area to determine complete removal of the spilled material.

The Contractor shall be responsible for transporting and disposing all material classified as a non-special waste, special waste, or hazardous waste from the job site to an appropriately permitted landfill facility. The transporter and the vehicles used for transportation shall comply with all federal, state, and local rules and regulations governing the transportation of non-special waste, special waste, or hazardous waste.

The Contractor shall line all equipment used by the Contractor to haul contaminated material to the landfill facility with a 6 mil (150 micron) polyethylene liner and provide secure cover during transportation. The Contractor shall obtain all documentation including any permits and/or licenses required to transport the contaminated material to the disposal facility.

The Engineer shall coordinate with the Contractor on the completion of all documentation. The Contractor shall make all arrangements for testing and waste disposal approval with the disposal facility. Subsequent to the Contractor completing these activities and upon receipt of authorization from the Engineer, the Contractor shall initiate the disposal process.

The Contractor shall provide the Engineer with all transport-related documentation within two days of transport or receipt of said document(s). The Engineer shall maintain the file for all such documentation. For management of special or hazardous waste, the Contractor shall provide the Engineer with documentation the Contractor (or subcontractor, if a subcontractor is used for transportation) is operating with a valid Illinois special waste transporter permit at least two weeks before transporting the first load of contaminated material.

The Contractor shall schedule and arrange the transport and disposal of each load of contaminated material produced. The Contractor shall make all transport and disposal arrangements to ensure no contaminated material remains within the project area at the close of business each day. Exceptions to this specification require prior approval from the Engineer within 24 hours of close of business. The Contractor shall be responsible for all other pre-disposal/transport preparations necessary on a daily basis to accomplish management activities.

Any waste generated as a special or hazardous waste from a non-fixed facility shall be manifested off-site using the Department's county generator number. An authorized representative of the Department shall sign all manifests for the disposal of the contaminated material and confirm the Contractor's transported volume. Any waste generated as a non-special waste may be managed off-site without a manifest, a special waste transporter, and a generator number.

The Contractor shall select a landfill mandated by definition of the contaminant within the State of Illinois. The Department will review and accept or reject the facility proposed by the Contractor to use as a landfill. The Contractor shall verify whether the selected disposal facility is in compliance with those applicable standards as mandated by definition of the contaminant and whether the disposal facility is presently, has previously been, or has never been, on the United States Environmental Protection Agency (U.S. EPA) National Priorities List or the Resource Conservation and Recovery Act (RCRA) List of Violating Facilities. The Contractor shall be responsible for coordinating permits with the IEPA. The use of a Contractor selected landfill shall in no manner delay the construction schedule or alter the Contractor's responsibilities as set forth.

The disposal of all materials, wastes, effluents, trash, garbage, oil, grease, chemicals, etc., in undesignated areas within the project will not be permitted. The Contractor shall remove the waste material placed in authorized areas and restore the area to its original condition. The Contractor shall excavate and dispose of, as directed by the Engineer, any project area soils affected by the Contractor's unauthorized disposal actions.

669.10 Non-Special Waste Certification. An authorized representative of the Department shall sign and date all non-special waste certifications. The Contractor shall be responsible for providing the Engineer with the required information that will allow the Engineer to certify the waste is not a special waste.

(a) Definition. A waste is considered a non-special waste as long as it is not:

- (1) a potentially infectious medical waste;
- (2) a hazardous waste as defined in 35 IAC 721;
- (3) an industrial process waste or pollution control waste that contains liquids, as determined using the paint filter test set forth in subdivision (3)(A) of subsection (m) of 35 IAC 811.107;
- (4) a regulated asbestos-containing waste material, as defined under the National Emission Standards for Hazardous Air Pollutants in 40 CFR 61.141;
- (5) a material containing polychlorinated biphenyls (PCB's) regulated pursuant to 40 CFR Part 761;
- (6) a material subject to the waste analysis and recordkeeping requirements of 35 IAC 728.107 under land disposal restrictions of 35 IAC 728;

- (7) a waste material generated by processing recyclable metals by shredding and required to be managed as a special waste under Section 22.29 of the Environmental Protection Act; or
- (8) an empty portable device or container in which a special or hazardous waste has been stored, transported, treated, disposed of, or otherwise handled.

(b) Certification Information.

All information used to determine the waste is not a special waste shall be attached to the certification. The information shall include but not be limited to:

- (1) the means by which the generator has determined the waste is not a hazardous waste;
- (2) the means by which the generator has determined the waste is not a liquid;
- (3) if the waste undergoes testing, the analytic results obtained from testing, signed and dated by the person responsible for completing the analysis;
- (4) if the waste does not undergo testing, an explanation as to why no testing is needed;
- (5) a description of the process generating the waste; and
- (6) relevant material data safety sheets.

669.11 Temporary Staging. The Contractor shall excavate and dispose of all waste material as mandated by the contaminates without temporary staging. If circumstances require the Contractor to use temporary staging, he/she shall request, in writing, approval from the Engineer.

When approved, the Contractor shall prepare a secure location within the project area capable of housing containerized waste materials. The Contractor shall contain all waste material in leak-proof storage containers such as lined roll-off boxes or 55 gal (208 L) drums, or stored in bulk fashion on storage pads. The design and construction of such storage pad(s) for bulk materials shall be subject to approval by the Engineer. The Contractor shall place the staged storage containers on an all-weather gravel-packed, asphalt, or concrete surface. The Contractor shall maintain a clearance both above and beside the storage units to provide maneuverability during loading and unloading. The Contractor shall provide any assistance or equipment requested by the Engineer for authorized personnel to inspect and/or sample contents of each storage container. All containers and their contents shall remain intact and undisturbed by unauthorized persons until the manner of disposal is determined. The Contractor shall keep the storage containers covered, except when access is requested by authorized personnel of the Department. The Engineer shall authorize any additional material added to the contents of any storage container before being filled.

The Contractor shall ensure the staging area is enclosed (by a fence or other structure) to ensure direct access to the area is restricted, and he/she shall procure and place all required regulatory identification signs applicable to an area containing the waste material. The Contractor shall be responsible for all activities associated with the storage containers including, but not limited to, the procurement, transport, and labeling of the containers. The Contractor shall clearly mark all containers in permanent marker or paint with the date of waste generation, location and/or area of waste generation, and type of waste (e.g., decontamination water, contaminated clothing, etc.). The Contractor shall place these identifying markings on an exterior side surface of the container. The Contractor shall separately containerize each contaminated medium, i.e. contaminated clothing is placed in a separate container from decontamination water. Containers used to store liquids shall not be filled in excess of 80 percent of the rated capacity. The Contractor shall not use a storage container if visual inspection of the container reveals the presence of free liquids or other substances that could classify the material as a hazardous waste in the container.

The Department will not be responsible for any additional costs incurred, if mismanagement of the staging area, storage containers, or their contents by the Contractor results in excess cost expenditure for disposal or other material management requirements.

669.12 Underground Storage Tank Removal. Prior to removing an UST the Engineer shall determine whether the Department is considered an "owner" or "operator" of the UST as defined by the UST regulations. Ownership of the UST refers to the Department's owning title to the UST during storage, use or dispensing of regulated substances. The Department may be considered an "operator" of the UST if it has control of, or has responsibility for, the daily operation of the UST. The Department may however voluntarily undertake actions to remove an UST from the ground without being deemed an "operator" of the UST.

In the event the Department is deemed not to be the "owner" or "operator" of the UST, the OSFM pull permit shall reflect who was the past "owner" or "operator" of the UST. If the "owner" or "operator" cannot be determined from past UST registration documents from OSFM then the OSFM pull permit will state the "owner" or "operator" of the UST is unknown. The Department's Chief Counsel's Office will review all UST pull permits, prior to submitting any pull permit to the OSFM. No UST removal shall be done without notifying the District's Environmental Coordinator, obtaining a pull permit, and the presence of a representative of OSFM on-site during the UST pull. If the Department is not the "owner" or "operator" of the UST then it will not register the UST or pay any registration fee.

The Contractor shall take soil samples from the bottom and walls of the excavated area after all soil has been removed during the initial response action, to determine the level of contamination remaining in the ground. The Contractor shall be responsible for obtaining all permits required for pulling the UST, all notification to the OSFM, removing the UST with properly trained personnel, and removing and disposing of the tank and its contents.

In the event the UST is designated a leaking underground storage tank (LUST) by the OSFM's inspector, the Contractor shall notify the Engineer. Upon confirmation

of a release of contaminants from the UST the Contractor shall perform the following initial response actions:

- (a) Report the release to the Illinois Emergency Management Agency (IEMA) (e.g., by telephone or electronic mail) and provide them with whatever information is available ("owner" or "operator" shall be stated as the past registered "owner" or "operator", unknown, or the Department);
- (b) Take immediate action to prevent any further release of the regulated substance to the environment, which may include removing, at the Engineer's discretion, and disposing of 4 ft (1.2 m) of the backfill surrounding the LUST;
- (c) Identify and mitigate fire, explosion and vapor hazards;
- (d) Remove as much of the regulated substance from the UST system as necessary to prevent further release into the environment;
- (e) Visually inspect any above ground releases or exposed below ground releases and prevent further migration of the released substance into surrounding soils and groundwater; and
- (f) Continue to monitor and mitigate any additional fire and safety hazards posed by vapors and free product that have migrated from the UST excavation zone and entered into subsurface structures (such as sewers or basements).

All contents within the tank shall be removed, transported and disposed of, or recycled. The tank shall be removed and rendered empty according to IEPA definition. This work shall include all required documentation, according to State, Federal, and Local regulations and laws.

All uncontaminated concrete and soil removed during tank extraction may be used to backfill the excavation, at the discretion of the Engineer.

669.13 Underground Storage Tank Backfill. The Contractor shall furnish a cohesive soil for backfilling areas where an underground storage tank removal has occurred. Cohesive soil shall contain less than ten percent sand or larger grain-size particles, having at least 25 percent clay, and a plastic index greater than 15. Cohesive backfill will not be required to backfill the sewer trenches and appurtenances constructed or any areas beneath pavement where an underground storage tank removal has occurred.

After backfilling the excavation, the site shall be graded and cleaned. This work shall be done according to the applicable portions of Section 205, 208, and 550.

669.14 Project Reports. Interim and final reports shall be as follows.

- (a) Interim Reports. The Contractor shall be responsible for submitting two copies of a report to the Engineer on a monthly or quarterly basis regarding the management and/or monitoring of non-special waste, special waste or hazardous waste. One additional copy of the technical report shall be sent

to the District's Environmental Studies Unit. The reports shall include all pertinent information regarding the project including, but not limited to:

- (1) The main issues during the reporting period,
 - (2) Activities/progress during the period,
 - (3) Major deliverables/submittals,
 - (4) Upcoming events/anticipated activities next period,
 - (5) Key personnel changes, and
 - (6) Subcontracting.
 - (7) Plans showing the areas of contamination,
 - (8) Cost of identifying, monitoring, handling, and disposing of contaminated soil or groundwater, the cost of preventing further migration of contaminants, and the cost for worker protection. All cost should be in the format of the contract pay items listed in the contract plans.
- (b) Final Reports. At the end of the project, the Contractor will prepare a technical report on the activities conducted during the life of the project and submit three copies to the Engineer. One additional copy of the technical report shall be sent to the District's Environmental Studies Unit and one additional copy of the technical report shall be sent to the Geologic and Waste Assessment Unit, Bureau of Design and Environment, IDOT, 2300 South Dirksen Parkway, Springfield, Illinois 62764. All project records shall be submitted to the Engineer. The technical report shall include all pertinent information regarding the project including, but not limited to:
- (1) Measures taken to identify, monitor, handle, and dispose of contaminated soil or groundwater, to prevent further migration of contaminants, and to protect workers,
 - (2) Cost of identifying, monitoring, handling, and disposing of contaminated soil or groundwater, the cost of preventing further migration of contaminants, and the cost for worker protection. All cost should be in the format of the contract pay items listed in the contract plans,
 - (3) Plans showing the areas of contamination,
 - (4) Field sampling and testing results,
 - (5) Hourly records of Contractors and subcontractors broken down by site,
 - (6) Waste manifests (identified by site) for special or hazardous waste disposal, and
 - (7) Landfill tickets (identified by site) for non-special waste disposal.

669.15 Method of Measurement. Non-special waste, special waste, and hazardous waste soil will be measured for payment according to Article 202.07(b) when performing earth excavation, Article 502.12(b) when excavating for structures, or by computing the volume of the trench using the maximum trench width permitted and the actual depth of the trench.

Groundwater disposal will be measured for payment in gallons (liters).

Backfill plugs will be measured in cubic yards (cubic meters) in place, except the quantity for which payment will be made shall not exceed the volume of the trench, as computed by using the maximum width of trench permitted by the Specifications and the actual depth of the trench, with a deduction for the volume of the pipe.

669.16 Basis of Payment. Underground storage tank removal, soil excavation, soil and content sampling, and the excavated soil, UST content, and UST disposal will be paid for at the contract unit price per each for UNDERGROUND STORAGE TANK REMOVAL.

The excavation, transportation, and disposal of soil and other materials from an excavation determined to be contaminated will be paid for at the contract unit price per cubic yard (cubic meter) for NON-SPECIAL WASTE DISPOSAL, SPECIAL WASTE DISPOSAL, or HAZARDOUS WASTE DISPOSAL.

The disposal of groundwater from an excavation determined to be contaminated will be paid for at the contract unit price per gallon (liter) for SPECIAL WASTE GROUNDWATER DISPOSAL or HAZARDOUS WASTE GROUNDWATER DISPOSAL.

The preparation, administration, and execution of the Site Safety and Health Plan, Site Contamination Operation Plan, Erosion Control Plan, and Reports will be paid for at the lump sum price for SPECIAL WASTE PLANS AND REPORTS.

When the contaminants of concern are gasoline only, soil or groundwater samples shall be analyzed for benzene, ethylbenzene, toluene, and xylenes (BETX). The analysis will be paid for at the contract unit price per each for BETX SOIL ANALYSIS and/or BETX GROUNDWATER ANALYSIS using EPA Method 8021B. This price shall include transporting the sample from the job site to the laboratory.

When the contaminants of concern are middle distillate and heavy ends, soil or groundwater samples shall be analyzed for BETX and polynuclear aromatics (PNAS). The analysis will be paid for at the contract unit price per each for BETX-PNAS SOIL ANALYSIS and/or BETX-PNAS GROUNDWATER ANALYSIS using EPA Method 8021B for BETX and EPA Method 8310 for PNAs. This price shall include transporting the sample from the job site to the laboratory.

When the contaminants of concern are used oils, soil samples shall be analyzed for priority pollutant volatile organic compounds (VOCs), priority, pollutants semi-volatile organic compounds (SVOCs), and priority pollutants metals. The analysis will be paid for at the contract unit price per each for PRIORITY POLLUTANTS SOIL ANALYSIS using EPA Method 8260B for VOCs, EPA Method 8270C for SVOCs, and using an ICP instrument and EPA Methods 6010B and 7471A for metals. This price shall include transporting the sample from the job site to the laboratory.

When the contaminants of concern are unknowns or non-petroleum material, soil samples shall be analyzed for priority pollutant VOCs, SVOCS, priority pollutants metals, pesticides, and RCRA metals by TCLP. The analysis will be paid for at the contract unit price per each for target compound list TCL SOIL ANALYSIS using EPA Method 8260B for VOCs, EPA Method 8270C for SVOCS, EPA Method 8081 for pesticides, and ICP instrument and EPA Methods 6010B, 7471A, 1311 (extraction), 6010B, and 7470A for metals. This price shall include transporting the sample from the job site to the laboratory.

When the waste material for disposal requires sampling for disposal acceptance, the samples shall be analyzed for TCLP VOCs, SVOCS, RCRA metals, pH, flash point, and paint filter. The analysis will be paid for at the contract unit price per each for SOIL DISPOSAL ANALYSIS using EPA Methods 1311 (extraction), 8260B for VOCs, 8270C for SVOCS, 6010B and 7470A for RCRA metals, 9045C for pH, 1030 for flash point, and 9095A for paint filter. This price shall include transporting the sample from the job site to the laboratory.

When the contaminants of concern are used oils, non-petroleum material, or unknowns, groundwater samples shall be analyzed priority pollutant volatile organics compounds (VOCs), priority pollutants semi-volatile organics compounds (SVOCS), and priority pollutants metals. The analysis will be paid for at the contract unit price per each for PRIORITY POLLUTANTS GROUNDWATER ANALYSIS using EPA Method 8260B for VOCs, EPA Method 8270C for SVOCS, and EPA Methods 6010B and 7470A for metals. This price shall include transporting the sample from the job site to the laboratory.

Backfill plugs will be paid for at the contract unit price per cubic yard (cubic meter) for BACKFILL PLUGS.

Payment for temporary staging, if required, will be paid for according to Article 109.04.

Payment for accumulated stormwater removal and disposal will be according to Article 109.04. Payment will only be allowed if appropriate stormwater and erosion control methods were used.

Payment for decontamination, labor, material, and equipment for monitoring areas beyond the specified areas, with the Engineer's prior written approval, will be according to Article 109.04.

SECTION 670. ENGINEER'S FIELD OFFICE AND LABORATORY

670.01 Description. This work shall consist of furnishing and maintaining in good condition for the exclusive use of the Engineer a weatherproof building or buildings hereinafter described at locations approved by the Engineer. Unless otherwise provided, the building shall be independent of any building used by the Contractor and all keys to the buildings shall be turned over to the Engineer. The Engineer will designate the location of the building and it shall remain on the work site until released by the Engineer.

Each field office or laboratory furnished shall be equipped with fire extinguishers having a minimum underwriters laboratory rating of 4A60BC.

670.02 Engineer's Field Office Type A. Type A field offices shall have a minimum ceiling height of 7 ft (2 m) and a minimum floor space of 450 sq ft (42 sq m). The office shall be provided with sufficient heat, natural and artificial light, and air conditioning.

The office shall have an electronic security system that will respond to any breach of exterior doors and windows. Doors and windows shall be equipped with locks. Doors shall also be equipped with dead bolt locks or other secondary locking device.

Windows shall be equipped with exterior screens to allow adequate ventilation. All windows shall be equipped with interior shades, curtains, or blinds. Adequate all-weather parking space shall be available to accommodate a minimum of ten vehicles.

Suitable on-site sanitary facilities meeting Federal, State, and local health department requirements shall be provided, maintained clean and in good working condition, and shall be stocked with lavatory and sanitary supplies at all times.

Sanitary facilities shall include hot and cold potable running water, lavatory and toilet as an integral part of the office where available. Solid waste disposal consisting of two waste baskets and an outside trash container of sufficient size to accommodate a weekly provided pick-up service.

In addition, the following furniture and equipment shall be furnished.

- (a) Four desks with minimum working surface 42 x 30 in. (1.1 m x 750 mm) each and five non-folding chairs with upholstered seats and backs.
- (b) One desk with minimum working surface 48 x 72 in. (1.2 x 1.8 m) with height adjustment of 23 to 30 in. (585 to 750 mm).
- (c) One four-post drafting table with minimum top size of 37 1/2 x 48 in. (950 mm x 1.2 m). The top shall be basswood or equivalent and capable of being tilted through an angle of 50 degrees. An adjustable height drafting stool with upholstered seat and back shall also be provided.
- (d) Two free standing four drawer legal size file cabinet with lock and an underwriters' laboratories insulated file device 350 degrees one hour rating.

- (e) One 6 ft (1.8 m) folding table with six folding chairs.
- (f) One equipment cabinet of minimum inside dimension of 44 in. (1100 mm) high x 24 in. (600 mm) wide x 30 in. (750 mm) deep with lock. The walls shall be of steel with a 3/32 in. (2 mm) minimum thickness with concealed hinges and enclosed lock constructed in such a manner as to prevent entry by force. The cabinet assembly shall be permanently attached to a structural element of the field office in a manner to prevent theft of the entire cabinet.
- (g) One refrigerator with a minimum size of 16 cu ft (0.45 cu m) with a freezer unit.
- (h) One electric desk type tape printing calculator.
- (i) A minimum of two communication paths. The configuration shall include:
 - (1) Internet Connection. An internet service connection using telephone DSL, cable broadband, or CDMA wireless technology. Additionally, an 802.11g/N wireless router shall be provided, which will allow connection by the Engineer and up to four Department staff.
 - (2) Telephone Lines. Three separate telephone lines.
- (j) One plain paper copy machine capable of reproducing prints up to 11 x 17 in. (280 x 432 mm) with an automatic feed tray capable of storing 30 sheets of paper. Letter size and 11 x 17 in. (280 x 432 mm) paper shall be provided.
- (k) One plain paper fax machine with paper.
- (l) Two telephones, with touch tone, where available, and a digital telephone answering machine, for exclusive use by the Engineer.
- (m) One electric water cooler dispenser.
- (n) One first-aid cabinet fully equipped.
- (o) One microwave oven, 1 cu ft (0.03 cu m) minimum capacity.
- (p) One fire-proof safe, 0.5 cu ft (0.01 cu m) minimum capacity.
- (q) One electric paper shredder.
- (r) One post mounted rain gauge, located on the project site for each 5 miles (8 km) of project length.

670.03 Reserved.

670.04 Engineer's Field Office Type B. Type B field offices shall have a minimum ceiling height of 7 ft (2 m) and a minimum floor space of 380 sq ft (35 sq m).

The office shall be provided with sufficient heat, natural and artificial light, and air conditioning. Doors and windows shall be equipped with locks approved by the Engineer.

Adequate all weather parking shall be available to accommodate a minimum of six vehicles.

In addition, the following equipment and furniture meeting the approval of the Engineer shall be furnished.

- (a) Four desks with minimum working surface 42 x 30 in. (1.1 m x 750 mm) each and four non-folding chairs with upholstered seats and backs.
- (b) One free standing four drawer legal size file cabinet with lock and an underwriters' laboratories insulated file device 350 degrees one hour rating.
- (c) One four-post drafting table with minimum top size of 37 1/2 x 48 in. (950 mm x 1.2 m). The top shall be basswood or equivalent and capable of being tilted through an angle of 50 degrees. An adjustable height drafting stool with upholstered seat and back shall also be provided.
- (d) Two folding chairs.
- (e) One equipment cabinet of minimum inside dimension of 44 in. (1100 mm) high x 24 in. (600 mm) wide x 30 in. (750 mm) deep with lock. The walls shall be of steel with a 3/32 in. (2 mm) minimum thickness with concealed hinges and enclosed lock constructed to prevent entry by force. The cabinet assembly shall be permanently attached to a structural element of the field office to prevent theft of the entire cabinet.
- (f) A minimum of two communication paths. The configuration shall include:
 - (1) Internet Connection. An internet service connection using telephone DSL, cable broadband, or CDMA wireless technology. Additionally, an 802.11g/N wireless router shall be provided, which will allow connection by the Engineer and up to four Department staff.
 - (2) Telephone Lines. Two separate telephone lines.
- (g) One electric desk type tape printing calculator.
- (h) One first-aid cabinet fully equipped.
- (i) One plain paper copy machine capable of reproducing prints up to 8 1/2 x 11 in. (215 x 280 mm) with an automatic feed tray capable of storing 30 sheets of paper.
- (j) One plain paper fax machine with paper.
- (k) One telephone, with touch tone, where available, and a digital telephone answering machine, for exclusive use by the Engineer.

- (l) A portable toilet meeting Federal, State, and local health department requirements stocked with lavatory and sanitary supplies at all times.
- (m) One electric water cooler dispenser.
- (n) One refrigerator with a minimum size of 16 cu ft (0.45 cu m) with a freezer unit.

670.05 Engineer's Field Laboratory. The field laboratory shall have a ceiling height of not less than 7 ft (2 m) and a floor space of not less than 200 sq ft (18.5 sq m). The laboratory shall be provided with sufficient heat, natural and artificial light, and air conditioning. Sanitary facilities as specified for Engineer's Field Office Type A shall also be included. Doors and windows shall be equipped with locks approved by the Engineer.

In addition, the following equipment and furniture meeting the approval of the Engineer shall be furnished:

- (a) One desk and chair
- (b) One drafting stool
- (c) One chair
- (d) One file cabinet, letter size, two drawer
- (e) One electric calculator
- (f) One telephone (for exclusive use by the Engineer)
- (g) One first-aid cabinet fully equipped
- (h) One service sink and water supply for testing purposes
- (i) One work bench 3 x 10 x 3 ft (1 x 3 x 1 m) high with drawers and cabinets below and three 110 volt, 20 amp outlets above the bench.

670.06 Mobile Units. With the approval of the Engineer, a mobile unit or units of approximately the same dimensions and having similar facilities may be substituted for the above described building or buildings.

All mobile field offices and laboratories shall be tied down near the four corners at each end of the mobile unit. The tie-down equipment shall be of the type commonly sold by mobile home equipment suppliers to protect mobile homes in areas affected by hurricanes. The tie-down shall be made to the satisfaction of the Engineer.

The mobile unit shall be securely supported by adequate blocking. The blocking shall provide a foundation to prevent settlement.

A landing of minimum 3 x 3 ft (1 x 1 m) dimension shall be provided at each doorway with integral steps and railings.

670.07 Basis of Payment. The building or buildings fully equipped as specified will be paid for on a monthly basis until the building or buildings are released by the Engineer. The Contractor will be paid the contract bid price each month provided the building or buildings are maintained, equipped, and utilities furnished. Payment will not be made when the contract is suspended according to Article 108.07 for failure of the Contractor to comply with the provisions of the contract. The building or buildings fully equipped, will be paid for at the contract unit price per calendar month or fraction thereof for ENGINEER'S FIELD OFFICE TYPE A, ENGINEER'S FIELD OFFICE TYPE B, or ENGINEER'S FIELD LABORATORY. This price shall include all utility costs and shall reflect the salvage value of the building or buildings, equipment, and furniture which become the property of the Contractor after release by the Engineer, except that the Department will pay that portion of the monthly long distance and monthly local telephone bills that, when combined, exceed \$150.

Any extraordinary damage attributed to State operations during the course of the job will be repaired by the Contractor and may be paid for according to Article 109.04. No extra payment will be made for systems maintenance, repairs or replacement, or for damages incurred as a result of vandalism, theft, or other criminal activities.

SECTION 671. MOBILIZATION

671.01 Description. This work shall consist of preparatory work and operations necessary for the movement of personnel, equipment, supplies, and incidentals to the project site for the establishment of offices, buildings, and other facilities necessary for work on the project and for all other work or operations which must be performed or costs incurred when beginning work on the project.

671.02 Basis of Payment. This work will be paid for at the lump sum price for MOBILIZATION. The amount which a Contractor will receive payment for, according to the following schedule, will be limited to six percent of the original contract amount. Should the bid for mobilization exceed six percent, the amount over six percent will not be paid until 90 percent of the adjusted contract value is earned.

- (a) Upon execution of the contract, 75 percent of the pay item will be paid.
- (b) When ten percent of the original contract amount is earned, an additional 15 percent of the pay item will be paid.
- (c) When 90 percent of the adjusted contract value is earned, the remaining ten percent of the pay item will be paid along with any amount bid in excess of six percent of the original contract amount.

Nothing herein shall be construed to limit or preclude partial payment for other items as provided for by the contract.

SECTION 672. SEALING ABANDONED WELLS

672.01 Description. This work shall consist of sealing abandoned water wells and monitoring wells.

CONSTRUCTION REQUIREMENTS

672.02 General. Work shall be performed according to the "Illinois Water Well Construction Code" (77 Illinois Administrative Code 920) and shall be performed by a licensed water well driller. A list of licensed water well drillers is available from the Illinois Department of Public Health offices in Springfield.

Any available information, such as well type, diameter, depth, and geologic data will be shown on the plans. Unless otherwise noted, monitoring wells are assumed to be 2 in. (50 mm) in diameter and a maximum of 25 ft (7.6 m) deep.

672.03 Basis of Payment. This work will be paid for at the contract unit price per each for SEALING ABANDONED WATER WELLS or SEALING ABANDONED MONITORING WELLS.

**DIVISION 700. WORK ZONE TRAFFIC CONTROL
AND PROTECTION, SIGNING, AND PAVEMENT MARKING**

SECTION 701. WORK ZONE TRAFFIC CONTROL AND PROTECTION

701.01 Description. This work shall consist of the furnishing, installation, maintenance, relocation, and removal of work zone traffic control and protection.

701.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Sign Posts, Metal (Note 1)	1093.01(a)
(b) Sign Posts, Wood (Note 2)	1007.05
(c) Pavement Marking Tape	1095.06

Note 1. Galvanizing of metal posts will not be required.

Note 2. The nominal size of wood posts shall be 4 x 4 in. (100 x 100 mm).

CONSTRUCTION REQUIREMENTS

701.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Signs	1106.01
(b) Flagger Traffic Control Paddle	1106.01
(c) Lights	1106.02
(d) Cones	1106.02
(e) Type I, II, and III Barricades	1106.02
(f) Vertical Barricades	1106.02
(g) Vertical Panels	1106.02
(h) Direction Indicator Barricades	1106.02
(i) Drums	1106.02
(j) Flexible Delineators	1106.02
(k) Truck Mounted/Trailer Mounted Attenuators	1106.02
(l) Arrow Boards	1106.02
(m) Portable Changeable Message Signs	1106.02
(n) Sign Trailers	1106.02
(o) Temporary Rumble Strips	1106.03

701.04 General. Work zone traffic control and protection shall be according to the traffic control plan and the MUTCD.

The traffic control shown on the plans represents the minimum required combination of traffic control devices needed for a particular construction operation. Conditions created by the Contractor's operation which are not covered by the plans shall be delineated by devices as directed by the Engineer at no additional cost to the Department. Revisions or modifications of the traffic control shall have the Engineer's written approval.

Traffic control shall be installed sequentially in the direction of the traffic flow and removed in reverse order. Advance warning signs shall be erected prior to channelizing devices and shall remain until all devices have been removed from the pavement.

The traffic control shall remain in place only as long as needed and shall be removed when directed by the Engineer. Signs that do not apply to current conditions shall be removed, covered, or turned from the view of motorists. All existing pavement markings which conflict with the revised traffic pattern shall be removed according to Section 783.

At the preconstruction conference, the Contractor shall furnish the name and telephone number of the individual in the Contractor's direct employ who is to be responsible, 24 hours-a-day, for the installation and maintenance of traffic control for the project. When the actual installation and maintenance are to be accomplished by a subcontractor, consent shall be requested of the Engineer at the time of the preconstruction conference. This shall not relieve the Contractor of furnishing a responsible individual in the Contractor's direct employ. The Department will provide the Contractor with the name of its representative who will be responsible for administration of the traffic control.

701.05 Maximum Length of Lane Closure. The maximum length of lane closure on multilane highways shall not exceed one day's production or 3 miles (5 km), whichever is less, except lane closures up to 5 miles (8 km) in length will be permitted for portland cement concrete patching and continuously reinforced concrete patching operations. Gaps between successive lane closures shall not be less than 2 miles (3 km) in length.

701.06 Minimum Lane Width. The minimum lane width adjacent to a closed lane during paving, patching, and other moving operations on freeways and expressways shall be a minimum of 10 ft (3 m). The 10 ft (3 m) shall be clear, unobstructed, and free of channelizing devices or other obstacles.

Where the clear width through a work zone with temporary concrete barrier will be 16.0 ft (4.88 m) or less, the Contractor shall notify the Engineer at least 21 days in advance of implementing the traffic control for that restriction.

701.07 Drop-offs. The maximum allowable differential in elevation between adjacent open traffic lanes shall be 1 1/2 in. (40 mm) for a vertical milled face, or 2 in. (50 mm) for a lift of HMA resurfacing.

When HMA resurfacing is being constructed and the road is opened to traffic, there shall be no more than 4 lane miles (6.5 lane km) of new binder or surface adjacent to the shoulder without either completing the shoulders, providing barricades or vertical panels, erecting "LOW SHOULDER" signs at 2 mile (3 km) intervals, or constructing a temporary earth wedge against the edge of pavement and compacting it to the satisfaction of the Engineer.

At locations where construction operations result in a differential in elevation exceeding 3 in. (75 mm) between the edge of pavement or edge of shoulder within 3 ft (900 mm) of the edge of the pavement and the earth or aggregate shoulders, Type I or II barricades or vertical panels shall be placed at 100 ft (30 m) centers on

roadways where the posted speed limit is 45 mph or greater and at 50 ft (15 m) centers on roadways where the posted speed limit is less than 45 mph.

Where construction operations result in a temporary drop-off at the edge of a completed stabilized shoulder and the road has a posted speed limit of 55 mph or greater and is open to traffic, "SHOULDER DROP-OFF" (W21-1103) signs shall be used. The Contractor shall place the signs at the beginning of the drop-off area, just beyond freeway interchanges or major intersections on non-freeways, and at such other locations within the drop-off area as the Engineer may direct to ensure a nominal spacing of 2 miles (3 km). The signs shall be placed just prior to the work which will result in the drop-off and shall remain in place until the drop-off is eliminated.

On ramps, drop-offs at the edge of pavement greater than 1 1/2 in. (40 mm) caused by the Contractor's operations will be allowed only on one side of the ramp at a time.

701.08 Contractor's Operations and Equipment. The Contractor shall keep all equipment, material, and vehicles off the pavement and shoulders on the side of the pavement which is open to traffic. Except where controlled by flaggers, the Contractor shall operate vehicles and equipment in the direction of traffic while traveling and working on the pavement and shoulders of a two-lane two-way highway. On a multilane highway, the Contractor shall operate vehicles and equipment in the direction of traffic while traveling and working on the pavement and shoulders.

Excavation for construction on both sides of the pavement at any one location at the same time will not be permitted. At any location on existing pavements less than three lanes in width, the sequence of construction shall limit operations to one side of the pavement.

701.09 Use of Median Crossovers. The Contractor will be permitted to make "U" turns across the median at existing maintenance crossovers or crossovers constructed by the Contractor, provided the width of the crossover is adequate to ensure no disruption of traffic on the through lanes and at locations permitted by the Engineer. The use of median crossovers will not be permitted within 1320 ft (400 m) of the speed change taper of an interchange ramp, within 2000 ft (600 m) of the taper for a lane closure, or when the construction traffic will be entering or exiting the only open lane within a construction zone. Crossovers shall also conform to minimum sight distance requirements.

While the crossover is being used, two signs shall be placed in the median and two signs shall be placed opposite on the outside shoulder of the highway in advance of the crossover on the side where trucks enter the highway. The first pair, approximately 1000 ft (300 m) from the crossover, shall be 48 in. (1.2 m) "MERGE RIGHT" signs. The second pair, approximately 1500 ft (450 m) from the crossover, shall be 48 in. (1.2 m) "TRUCKS ENTERING ON LEFT" signs. The warning signs in advance of the crossover in the other direction shall be as listed above, except the second pair shall be "TRUCKS LEAVING ON LEFT".

701.10 Surveillance. When open holes, broken pavement, trenches over 3 in. (75 mm) deep and 4 in. (100 mm) wide or other hazards are present within 8 ft (2.4 m) of the edge of an open lane, the Contractor shall furnish traffic control

surveillance during all hours when the Contractor is not engaged in construction operations. The surveillance person(s) shall be provided with adequate transportation and communications to ensure deficiencies can be corrected. The surveillance person(s) shall drive over and inspect the work, maintain the temporary traffic control devices, and assist and direct traffic, at such intervals as may be required, not to exceed four hours. The person responsible for surveillance shall complete an inspection form, furnished by the Engineer, on a daily basis. The completed form shall be given to the Engineer on the first working day after the inspection.

701.11 Equipment Parking and Storage. During working hours, all vehicles and/or nonoperating equipment which are parked, two hours or less, shall be parked at least 8 ft (2.5 m) from the open traffic lane. For other periods of time during working and for all nonworking hours, all vehicles, materials, and equipment shall be parked or stored a minimum of 30 ft (9 m) from the pavement when the project has adequate right-of-way. When adequate right-of-way does not exist, vehicles and materials shall be located at least 15 ft (4.5 m) from the edge of any pavement open to traffic, unless located behind temporary concrete barrier, temporary bridge rail, or other man-made or natural barriers. Temporary barriers erected for protection by the Contractor shall meet the approval of the Engineer.

Any unattended obstacle or excavation (not patching) in the work area which constitutes a hazard in the opinion of the Engineer, shall be delineated by devices at 50 ft (15 m) centers. If the hazard exceeds 250 ft (75 m) in length, the spacing of devices may be increased to 100 ft (30 m).

When not being utilized to inform and direct traffic, sign trailers, arrow boards, and portable changeable message boards shall be treated as nonoperating equipment.

701.12 Personal Protective Equipment. All personnel on foot, excluding flaggers, within the highway right-of-way shall wear a fluorescent orange, fluorescent yellow/green, or a combination of fluorescent orange and fluorescent yellow/green vest meeting the requirements of ANSI/ISEA 107-2004 for Conspicuity Class 2 garments. Other types of garments may be substituted for the vest as long as the garments have a manufacturer's tag identifying them as meeting the ANSI Class 2 requirement.

701.13 Flaggers. All flaggers shall be certified by an agency approved by the Department. While on the job site, each flagger shall have in his/her possession a current driver's license and a current flagger certification I.D. meeting Department requirements. For non-drivers, the Illinois Identification Card issued by the Secretary of State will meet the requirement for a current driver's license. This flagger certification requirement may be waived by the Engineer for emergency situations that arise due to actions beyond the Contractor's control where flagging is needed to maintain safe traffic control on a temporary basis.

The signaling methods used by flaggers shall comply with those contained in the Department's "Flagger Handbook".

Flaggers shall be stationed to the satisfaction of the Engineer and be equipped with a fluorescent orange, fluorescent yellow/green, or a combination of fluorescent

orange and fluorescent yellow/green vest meeting the requirements of ANSI/ISEA 107-2004 for Conspicuity Class 2 garments and flagger traffic control paddles. The longitudinal placement of the flagger may be increased up to 100 ft (30 m) from that shown on the plans to improve the visibility of the flagger. Flaggers shall not encroach on the open lane of traffic unless traffic has been stopped.

For nighttime flagging, flaggers shall be illuminated by an overhead light source providing a minimum vertical illuminance of 10 fc (108 lux) measured 1 ft (300 mm) out from the flagger's chest. The bottom of any luminaire shall be a minimum of 10 ft (3 m) above the pavement. Luminaire(s) shall be shielded to minimize glare to approaching traffic and trespass light to adjoining properties.

Nighttime flaggers shall be equipped with a fluorescent orange or fluorescent orange and fluorescent yellow/green vest meeting the requirements of ANSI/ISEA 107-2004 for Conspicuity Class 3 garments.

Flaggers shall be provided per the traffic control plan and as follows.

- (a) Two Lane Highways. Two flaggers will be required for each separate operation where two-way traffic is maintained over one lane of pavement. Work operations controlled by flaggers shall be no more than 1 mile (1600 m) in length. Flaggers shall be in sight of each other or in direct communication at all times. Direct communication shall be obtained by using portable two-way radios or walkie-talkies.

An additional flagger will be required at each side road within the operation where two-way traffic is maintained on one lane of pavement.

- (b) Multilane Highways. At all times where traffic is restricted to less than the normal number of lanes on a multilane pavement with a posted speed limit greater than 40 mph and the workers are present, but not separated from the traffic by physical barriers, a flagger shall be furnished to support the workers and to warn and direct traffic. One flagger will be required for each separate activity of an operation that requires frequent encroachment in a lane open to traffic.

Flaggers will not be required when no work is being performed, unless there is a lane closure on two-lane, two-way pavement.

701.14 Signs. When work operations exceed four days, signs shall be post mounted unless the signs are located on the pavement or define a moving or intermittent operation. When approved by the Engineer, temporary sign supports may be used where posts are impractical. When post mounting is not required, either temporary sign supports or sign trailers may be used.

Post mounted signs shall be a breakaway design. The sign shall be within five degrees of vertical. Two posts shall be used for signs greater than 16 sq ft (1.5 sq m) in area or where the height between the sign and the ground exceeds 7 ft (2.1 m).

Signs on temporary supports shall meet the requirements of NCHRP Report 350 or MASH. Documentation of meeting the requirements shall be the FHWA letter stating acceptance of the sign support system for the required test level. The signs

shall be supported within 20 degrees of vertical. Weights used to stabilize signs shall be attached to the sign support as per the manufacturer's specifications.

Sign trailers, when erected, shall have their tires resting on the ground or elevated a maximum of 6 in. (150 mm) above the ground. Weights used to stabilize the trailer shall be sandbags mounted a maximum of 12 in. (300 mm) above the ground. To prevent wind induced rolling of the trailer, the wheels shall be chocked with sandbags or the trailer tongue may be pinned. The pinning method shall be designed to give way in the event of a vehicular impact and shall meet the approval of the Engineer.

The sign trailer shall only be attached to its tow vehicle when the sign is actually being moved. The tow vehicle, when not attached to the trailer, shall be parked according to Article 701.11.

Longitudinal dimensions shown on the plans for the placement of signs may be increased up to 100 ft (30 m) to avoid obstacles, hazards, or to improve sight distance, when approved by the Engineer.

- (a) "ROAD CONSTRUCTION AHEAD" Signs. "ROAD CONSTRUCTION AHEAD" signs shall be erected on all side roads located within the limits of the mainline "ROAD CONSTRUCTION AHEAD" signs.
- (b) Work Zone Speed Limit Signs. Work zone speed limit sign assemblies shall be provided and located as shown on the plans. Two additional assemblies shall be placed 500 ft (150 m) beyond the last entrance ramp for each interchange or sideroad.

All permanent "SPEED LIMIT" signs located within the work zone shall be removed or covered. This work shall be coordinated with the lane closure(s) by promptly establishing a reduced posted speed zone when the lane closure(s) are put into effect and promptly reinstating the posted speed zone when the lane closure(s) are removed.

The work zone speed limit signs and end work zone speed limit signs shown in advance of and at the end of the lane closure(s) shall be used for the entire duration of the closure(s).

The work zone speed limit signs shown within the lane closure(s) shall only be used when workers are present in the closed lane adjacent to traffic. The sign assemblies shown within the lane closure(s) will not be required when the worker(s) are located behind a concrete barrier wall.

701.15 Traffic Control Devices. The number, type, color, size, and placement of traffic control devices shall be according to the traffic control plan, the MUTCD, and the Department's "Quality Standard for Work Zone Traffic Control Devices". Work shall not begin until the Engineer has determined the devices meet the quality requirements.

For devices that must meet FHWA crashworthiness standards, the Contractor shall provide a manufacturer's self-certification letter for each Category 1 device and a FHWA acceptance letter for each Category 2 and Category 3 device used on the

contract. The letter(s) shall state the device has been accepted by FHWA for its respective category and test level, and shall include a detailed drawing of the device. The set-up and use of certified/accepted devices shall be the same as that described in the letter.

All devices shall be kept clean. Any device which has become ineffective due to damage or defacement shall be replaced.

Devices having angled striping shall be oriented with the stripes sloping down toward the side on which traffic will pass. Lights on devices shall be mounted on the side of the device on which traffic shall pass and shall not obscure any reflectorized portion of the device.

Where more than one type of device is permissible, only one type of device shall be used within that individual run of devices or lane closure taper.

Additional requirements for the use of specific devices are as follows.

- (a) Cones. Cones are used to channelize traffic during daylight operations. Reflectorized cones are for nighttime operations, but shall only be used when specified in the plan or when approved by the Engineer.
- (b) Type I, II, and III Barricades. Type I and Type II barricades are used to channelize traffic; to delineate unattended obstacles, patches, excavations, drop-offs, and other hazards; and as check barricades.

Type I barricades are for use on roads with normal posted speeds of 40 mph or less. However, they may be used on higher speed roads provided the reflective area of the upper rail is at least 2 sq ft (0.18 sq m).

Type III barricades are used to close lanes and to close roads.

- (c) Vertical Barricades. Vertical barricades are used to channelize traffic, as well as to delineate unattended obstacles, patches, excavations, drop-offs, and other hazards. Vertical barricades shall not be used in lane closure tapers or as check barricades.
- (d) Vertical Panels. Vertical panels are used to channelize traffic and to delineate unattended excavations and drop-offs.
- (e) Direction Indicator Barricades. Direction indicator barricades are used in lane closure tapers.
- (f) Drums. Drums are used to channelize traffic and to delineate unattended obstacles, patches, excavations, drop-offs, and other hazards.
- (g) Flexible Delineators. Flexible delineators are used to channelize traffic. They shall only be used when specified.
- (h) Truck Mounted/Trailer Mounted Attenuators (TMA). TMA units shall have a roll ahead distance in the event of an impact. The TMA shall be between

100 and 200 ft (30 and 60 m) behind the vehicle ahead or the workers. This distance may be extended by the Engineer.

TMA host vehicles shall have the parking brake engaged when stationary.

The driver and passengers of the TMA host vehicle should exit the vehicle if the TMA is to remain stationary for 15 minutes or more in duration.

- (i) Arrow Boards. Arrow boards are used to warn motorists of an upcoming lane closure. Arrow boards shall not be used to direct passing moves into lanes used by opposing traffic or to shift traffic without having a lane change.

On roads with normal posted speeds of 45 mph and above, Type C units shall be used for all operations 24 hours or more in duration, and Type B units may be used for operations less than 24 hours in duration. On roads with normal posted speeds less than 45 mph, Type A, B, or C units may be used for all operations.

- (j) Portable Changeable Message Signs. These signs shall be furnished, placed, and maintained according to the traffic control plan and as directed by the Engineer.

The Contractor shall supply the modem, the cellular phone, and the necessary software to run the sign from a remote computer at a location designated by the Engineer. The Contractor shall promptly program and/or reprogram the computer to provide the messages as directed by the Engineer.

The Contractor shall provide all preventive maintenance efforts deemed necessary to achieve uninterrupted service. If service is interrupted for any cause and not restored within 24 hours, the Engineer will cause such work to be performed as may be necessary to provide this service and the cost of such work will be deducted from compensation due or which may become due the Contractor under the contract.

- (k) Temporary Rumble Strips. Temporary rumble strips shall be placed snugly against one another and attached to the pavement with an adhesive meeting the recommendations of the rumble strip manufacturer.

701.16 Lights. Lights shall be used on devices as required in the traffic control plan and the following table.

Circumstance	Lights Required
Daylight operations	None
First two warning signs on each approach to the work involving a nighttime lane closure	Flashing mono-directional lights
Devices delineating isolated obstacles, excavations, or hazards at night. (Does not apply to patching)	Flashing bi-directional lights
Devices delineating obstacles, excavations, or hazards exceeding 100 ft (30 m) in length at night. (Does not apply to widening)	Steady burn bi-directional lights
Channelizing devices for nighttime lane closures on two-lane roads	Steady burn bi-directional lights.
Channelizing devices for nighttime lane closures on multi-lane roads	Steady burn mono-directional lights
Devices in nighttime lane closure tapers	Steady burn mono-directional lights
Devices delineating a widening trench	None
Devices delineating patches at night on roadways with an ADT less than 25,000	None
Devices delineating patches at night on roadways with an ADT of 25,000 or more	Steady burn mono-directional lights

Batteries for the lights shall be replaced on a group basis at such times as may be specified by the Engineer.

701.17 Specific Construction Operations. Additional requirements for specific construction operations shall be as follows.

- (a) Portland Cement Concrete Shoulders. Portland cement concrete shoulders shall be opened to traffic according to Article 701.17(c)(5).
- (b) Base Course.
 - (1) Aggregate Base Course. The road or any section 1 mile (1.6 km) or more in length shall be opened to local traffic immediately after it has been completed.
 - (2) Soil-Cement Base Course. The finished soil-cement base course may be opened immediately to local traffic and to the Contractor's construction equipment. The base may be opened to all traffic after the seven day protection period, provided the base course is not damaged, marred, or distorted by such traffic, and provided the protection and cover specified in Article 352.13 is not impaired.

- (c) **Surface Courses and Pavement.** Where construction operations on two-lane roads open to traffic result in the removal or covering of any pavement striping indicating passing restrictions, "NO PASSING ZONES NOT STRIPED NEXT _ MILES" signs shall be used. The Contractor shall place the signs at the beginning of the unstriped area, just beyond each major intersection within the unstriped area, and at other locations as directed by the Engineer to ensure a minimum spacing of 5 miles (8 km). The signs shall be placed just prior to removal or covering of the striping and shall remain in place until full no passing zone striping has been restored.
- (1) **Prime Coat.** "FRESH OIL" (W21-2) signs shall be erected when prime and fine aggregate are applied to pavement that is open to traffic. The signs shall remain until tracking of the prime ceases as directed by the Engineer. The signs shall be erected a minimum of 500 ft (150 m) preceding the start of the prime.
 - (2) **Cold Milling.** "ROUGH GROOVED SURFACE" (W8-I107) signs shall be erected when the road has been cold milled and opened to traffic. The signs shall be placed just prior to the cold milling operation and shall remain in place until the milled surface condition no longer exists. These signs shall be erected a minimum of 500 ft (150 m) preceding the start of the milled pavement, just before each major intersection within the milled area, and at other locations as directed by the Engineer. The signs shall have an amber flashing light attached.
 - (3) **HMA Binder and Surface Course.** The road shall be kept open to traffic on the existing pavement or on the new work. During the actual cleaning of the pavement and the placing of the mixture for cracks, joints and flangeways, prime coat, leveling binder, binder and surface courses, one-way traffic will be permitted. At all other times, two-way traffic will be allowed to use the road.
 - (4) **Bituminous Surface Treatment.** The surface may be opened to traffic as soon as it has cured sufficiently to prevent the material from being picked up by the wheels of vehicles passing over it.
 - (5) **Portland Cement Concrete Pavement.** When the curing period for the pavement, according to Article 1020.13, has been completed and the joints have been sealed, as required in Article 420.12, and protective coat, when required, is applied, the Engineer will determine when the pavement shall be opened to traffic. The earliest the pavement will be opened to traffic will be when test specimens according to Article 1020.09 have attained a flexural strength of 650 psi (4,500 kPa) or a compressive strength of 3500 psi (24,000 kPa). If such tests are not conducted, the pavement shall not be opened to traffic until 14 days after the concrete is placed or until 28 days when fly ash or ground granulated blast-furnace slag is used in the concrete mixture. Prior to opening to traffic, the pavement shall be cleaned. The Contractor may request additional test specimens be made and tested if the Contractor wishes to open the pavement to traffic earlier than the normal testing frequency. All traffic including construction traffic shall be limited to legal axle weights (legal loads).

(d) Structures.

- (1) Concrete Superstructures. Concrete superstructures shall be opened to traffic according to Article 503.20.
- (2) Box and Pipe Culvert Extensions. Box culvert and pipe culvert extensions shall be delineated with barricades until the backfill over the extensions is complete and no longer poses a hazard to traffic.
- (3) Storm Sewers Jacked in Place. The construction operations shall be carried on without encroachment upon the traveled way by either the excavation or by the storage of equipment or materials. When open cut excavation encroaches upon the shoulder, the excavation shall be delineated according to Article 701.11.
- (4) Bridge Washing. The entire bridge roadway and roadways below shall be kept open to traffic at all times, other than when actual work is being performed. While actual work is being performed, one-half the roadway may be closed to traffic at the option of the Contractor. One-way traffic shall be permitted over the other half of the roadway if the bridge roadway is less than 40 ft (12.2 m) in width. Two-way traffic shall be permitted over the other half of the roadway if the bridge roadway width is 40 ft (12.2 m) or more between curbs. Traffic control devices shall be as specified for each bridge.

(e) Pavement Patching.

- (1) Keeping Road Open to Traffic. Traffic shall be permitted to use the road at all times and construction operations shall be arranged to facilitate the movement of traffic. On two-lane roadways, construction operations shall be confined to one traffic lane. On four-lane roadways, construction operations shall be confined to one traffic lane in each direction.

In addition to the traffic control and protection shown elsewhere in the contract for multi-lane pavement, two devices shall be placed immediately in front of each open patch, open hole, and broken pavement where temporary concrete barriers are not used to separate traffic from the work area. One device shall be placed at the edge of the open traffic lane and one device centered in the closed lane. A check barricade shall be placed in the middle of the closed lane and the adjacent shoulder at 1000 ft (300 m) centers.

- (2) Broken Pavement and Open Holes.

- a. Multilane Roadways. Prior to weekend or holiday periods, pavement broken and holes opened for patching shall be completed and the road fully opened. For HMA patching or when Class PP-2, PP-3, or PP-4 concrete is specified, no broken pavement, open holes, or partially filled patches shall remain overnight and all devices shall be removed before dark.

The total area of pavement broken and not removed for concrete patching shall not exceed 1/2 of the total area of broken pavement which can be removed in an average day's work. The total area of holes left open overnight for concrete patching shall not exceed 1/2 of the pavement area which can be replaced in an average day's work. No materials removed from patches shall remain on the right-of-way overnight.

- b. Two Lane Roadways and Ramps. No broken pavement, open holes, or partially filled patches shall remain overnight and all devices shall be removed before dark.

If patches are not opened when required, additional traffic control shall be provided at no additional cost to the Department.

(3) Opening Road to Traffic.

- a. Cleaning Up. Prior to opening the pavement to traffic, the entire right-of-way adjacent to the patching operations shall be cleared of all materials caused by the Contractor's operations, and the backfill along the shoulder edge of the pavement shall be compacted.
- b. Strength Tests. For patches constructed with Class PP-1 concrete, the pavement may be opened to traffic when test specimens have obtained a minimum flexural strength of 600 psi (4,150 kPa) or a minimum compressive strength of 3200 psi (22,100 kPa) according to Article 1020.09.

For patches constructed with Class PP-2, PP-3, PP-4, or PP-5 concrete, the pavement may be opened to traffic when test specimens have obtained a minimum flexural strength of 250 psi (1725 kPa) or a minimum compressive strength of 1600 psi (11,000 kPa) according to Article 1020.09. However, the concrete mixture shall obtain a minimum flexural strength of 600 psi (4150 kPa) or a minimum compressive strength of 3200 psi (22,100 kPa) in the time specified in Table 1 of Article 1020.04.

With the approval of the Engineer, concrete strength may be determined according to Illinois Modified AASHTO T 325.

- (f) Guardrail. Where guardrail is temporarily removed or where the guardrail installation is incomplete, devices shall be placed at 50 ft (15 m) centers.

On staged construction bridge projects, the parapets shall have the guardrail installed and attached prior to switching traffic.

Guardrail removal and/or installation shall be scheduled so no installations are left unfinished when the work is suspended for the winter or other extended periods of time.

701.18 Highway Standards Application. Standards for work zone traffic control shall be applied according to the traffic control plan. Additional requirements for specific Standards shall be as follows.

- (a) Standard 701006, 701011, and 701101. When the work operation requires four or more work vehicles enter through traffic lanes in a one hour period, a flagger shall be provided and a "FLAGGER" sign shall be substituted for the "WORKER" sign.
- (b) Standard 701316 and 701321. The exact location of the signals, detector loops, stop bars, and signs shall be as directed by the Engineer. The locations shall also be adjusted as required for staged construction.

The Engineer shall be notified at least 72 hours in advance of placing the signals in operation and at least one week prior to a traffic lane width reduction.

Any damage to the temporary traffic signals from any cause shall be repaired at no additional cost to the Department. If at any time the Contractor fails to perform any work deemed necessary by the Engineer to keep the temporary traffic signals in proper operating condition, the Department reserves the right to have other electrical Contractors perform the needed work, and the cost will be deducted from compensation due or which may become due the Contractor under the contract.

- (1) Standard 701316. During daytime operations when workers are present, the Engineer may allow Type I or Type II barricades to be placed parallel to the centerline. Cones may be substituted for barricades at half the barricade spacing during the daytime operations.
- (2) Lane Closure on Two-Way, Two-Lane Rural Road. The Contractor shall furnish, install, maintain, and remove temporary traffic signals including a traffic actuated controller, a cabinet, detector amplifiers, and other associated equipment as listed below and on Standards 701316 and 701321 for each location specified. The Contractor shall have available one spare controller and cabinet. The Contractor shall retain ownership of all traffic control equipment, miscellaneous accessories, and the installation methods shall be according to the following.
 - a. Traffic Signal Heads. Two signal heads shall be provided for each mainline approach and for each sideroad within the designated work area. All signal faces shall have new lamps when installed. When the signals are not operating, the signal head shall be hooded according to Article 880.03 and the "SIGNAL AHEAD" sign covered or removed. The left signal head shall be mounted at a height of 10 ft (3.1 m) above the road surface measured to the bottom of the signal head. The right signal head shall be mounted at a height of 14 ft (4.3 m) above the road surface. Back plates will be required on all signals.

The right signal head shall be aimed so the centers of the light beams of the indications are directed toward a point in the center of

the approach lane 500 ft (150 m) in advance of the signal. The left indication shall be aimed at a point in the center of the approach lane 100 ft (30 m) in advance of the stop line.

- b. Lenses. All lenses shall be 12 in. (300 mm) nominal diameter.
- c. Wire and Cable. The Contractor shall supply all overhead and underground wiring for both signal circuits and loop detector lead-ins. The electric cable shall be aerially suspended, at a minimum height of 8 ft (2.5 m) and as close to the right-of-way line as possible. When the electric cable crosses a roadway or entrance, it shall be aerially suspended, at a minimum height of 18 ft (5.5 m), according to the local utility requirements, or placed in a trench with a minimum of 2 in. (50 mm) of cover, or protected in a manner approved by the Engineer.
- d. Mounting. The controller shall be mounted on a post, pole, or temporary concrete foundation. The signal heads shall be mounted on 25 ft (7.5 m) standard tubular steel posts or on a minimum Class 4 wood pole, when overhead wiring is used between signals. Alternative methods of mounting the cabinet or signal heads shall be approved by the Engineer. The supports shall be kept in a vertical position for the duration of the project.
- e. Service Installation. The Contractor shall be responsible for the installation and cost of 110 V electrical service. When the service cable from the controller to the power source is suspended overhead, the line height shall not be less than 8 ft (2.5 m) above the ground and located as close to the right-of-way lines as practicable. When the cable crosses a roadway or entrance, the cable shall be raised to a minimum height of 18 ft (5.5 m) or pass under the pavement through a culvert opening. Portable power generating equipment may be used for a short period of time until local power is available, provided at least one person is present at all times at the site to ensure proper operation.
- f. Traffic Signal Controller.
 - 1. The controller shall be a standard eight phase NEMA controller housed in a weather proof cabinet. The traffic signals shall dwell in All-Red. The long All-Red intervals shall be adjustable up to 99 seconds in one second increments. Long All-Red intervals shall be obtained by using a trail green feature or an equivalent, or by using dummy phases. The long All-Red interval shall be pre-empted if the previous movement is detected before the conflicting movement is detected and shall cause the previous movement to return to the green display with a minimum four second delay. When a conflict or failure is detected, the signal shall display a flashing All-Red. When an additional phase is used for a side road movement, only one long red interval shall be used between active phases on each side of the work area.

All devices used, in lieu of controller software to produce this sequence, shall be mounted within the cabinet but not within the controller. The Contractor shall provide an operational demonstration of the controller assembly for the Engineer subsequent to installation and prior to being placed into operation. The Contractor shall program the controller, trouble shoot, and correct any problems that arise, and verify the equipment is functioning according to the contract. If any controller malfunction occurs during the time of operation or in the event of a power failure, the Contractor shall, without delay, provide flaggers for traffic control and immediately install a replacement controller to operate the signals.

2. When specified, the Department will furnish the traffic actuated controller. The controller, complete with loop detector-amplifiers and pole mount cabinet, shall be picked up and returned upon completion of the project to the location designated on the plans. The Contractor shall provide notice to the Department at least two weeks in advance of requiring the traffic actuated controller. The Contractor shall be responsible for maintenance of the controller and all related equipment within the controller cabinet. The controller shall be inspected by the Contractor and Engineer subsequent to installation and prior to being placed into operation. Any malfunction of the Department owned equipment revealed during the inspection by the Contractor shall be repaired and will be paid for according to Article 109.04. The Contractor shall be responsible for any damage to the Department-owned equipment as a result of negligence or poor workmanship during installation at his/her expense. The Contractor shall provide all maintenance required, at his/her expense, to keep the Department-owned equipment functioning properly after being placed in operation.
- g. Detector Loops. Three detector loops shall be installed on each approach as shown on the plans. The near detector loops shall be placed 12 in. (300 mm) from the centerline and the far loop shall be placed 12 in. (300 mm) from the edge line. Each loop shall be connected to a separate detector amplifier channel. Call delay feature shall be used for the loops nearest the stop lines and defeated during the green of that phase. An alternate method of detection may be used if it has been demonstrated and approved by the Department.

The loop detector lead-in cable shall be protected from construction and maintenance activities. In the event of detector loop failure, the Contractor shall have 48 hours to repair or replace the loops. Upon completion of the project, the detector loop shall be terminated in such a manner as to provide for future use.

- (c) Standard 701326. No paving or excavating operations shall be performed at night unless authorized by the Engineer.
- (d) Standard 701336. Two flaggers shall be required for each separate construction operation. The flagger shall be a minimum of 200 ft (60 m) and a maximum distance of 1/2 day's operation beyond the flagger sign and a minimum of 100 ft (30 m) in advance of the work party.

Under restricted sight distance conditions, additional devices may also be required for distances less than 2000 ft (600 m) at the discretion of the Engineer.

During periods when workers are present all work areas shall be delineated by cones or barricades along the centerline.

- (e) Standards 701400, 701401, 701406, 701421, 701422, and 701446.
 - (1) General. When Standards 701401 and 701422 are specified for overnight operations, cones may be substituted for barricades or drums at half the spacing during day operations.
 - (2) Multilane Pavement Resurfacing. For the construction of binder course, surface course and shoulder resurfacing on multilane pavements, Standards 701401, 701406, 701421, 701422, or 701446 shall be used from the beginning of business on Monday to 4:30 p.m. on Friday. Only Standards 701406 and 701421 shall be used from 4:30 p.m. Friday to start of business on Monday.
 - (3) Shoulder Upgrading and Replacement. The following shall apply to shoulder pipe underdrain installation and/or shoulder reconstruction on existing multilane divided highways.

The Contractor shall close the adjacent lane of pavement according to the Standards within the limits of the construction zone a) when required by the Contractor's operations and b) when no workers are present and the difference in elevation between the pavement and the shoulder and/or widening is greater than 12 in. (300 mm).

Standards 701401 and 701422 will only be measured for payment where the average depth of shoulder reconstruction required by the plans, exclusive of any trench for pipe underdrain installation, is in excess of 3 in. (75 mm). Where such shoulder reconstruction is 3 in. (75 mm) or less, no open trench greater than 3 in. (75 mm) deep will be permitted overnight. If, because of unforeseen circumstances, an open trench greater than 3 in. (75 mm) deep should occur overnight, the Contractor shall, at no additional cost to the Department, close the adjacent traffic lane according to Standards 701400 and 701401 or according to Standard 701422.

Excavations greater than 3 in. (75 mm) in depth between the pavement and shoulder, including any trenches within the shoulder area, shall be restricted to one shoulder in each direction of travel. In addition,

shoulder drop-offs greater than 1 1/2 in. (40 mm) caused by the Contractor's operations will not be permitted over the winter shutdown.

The Contractor shall schedule the work so the lane closure at any one work area does not exceed five working days. The closure time may be exceeded for conditions beyond the Contractor's control, except if continual and persistent closures in excess of the five working days are made, the Engineer will initiate measures to delay or limit the daily production of the Contractor's operations.

All debris shall be removed from the shoulder and right-of-way prior to the removal of barricades, drums, or vertical panels.

- (f) Standard 701416. A reflective solid edge line and yellow centerline for each direction of traffic shall be used when the closure time exceeds four days or when the normal posted speed outside the area of operations exceeds 50 mph. Reflectorized pavement marking tape shall be used for marking the edge lines and centerline on existing pavement. Either tape or reflectorized pavement marking paint may be used for markings on the paved crossovers. Raised reflective pavement markers at 25 ft (8 m) centers shall be installed for additional delineation.

Vertical panels may be attached to concrete barriers where available space prohibits the use of drums.

- (g) Standard 701431. Reflective solid edge lines and a double yellow centerline shall be used when the closure time exceeds four days or when the normal posted speed outside the area of operations exceeds 50 mph. Reflectorized pavement marking tape shall be used for marking the centerline and edge lines on the existing pavement. Raised reflective pavement markers at 25 ft (8 m) centers shall be installed under good weather conditions to supplement the pavement marking tape. All existing pavement markings which conflict with the revised traffic pattern shall be removed.

Devices no greater than 24 in. (600 mm) wide, may be used in place of flexible delineators when the two-way operation is to be in place four days or less.

- (h) Standard 701426. Truck mounted attenuators will not be required for any vehicle traveling entirely on a completed shoulder.
- (i) Standard 701411. This Standard shall supplement mainline traffic controls for lane closures.

The channelizing devices shall clearly define a path for motorists entering or exiting the highway.

Raised reflectorized pavement markers at 25 ft (8 m) centers may be used in lieu of tape where the pavement marking is to be placed adjacent to the barricades or drums.

- (j) Urban Traffic Control, Standards 701501, 701502, 701601, 701602, 701606, 701701, and 701801.

- (1) General. "NO PARKING" signs shall be installed throughout the work area.

When the work area is in the parking lane and parking exists during work hours, "ROAD CONSTRUCTION AHEAD" or "ROAD WORK AHEAD" signs shall be installed 200 ft (60 m) in advance of the work area and the area shall be delineated with cones or barricades.

Reflectorized temporary pavement marking tape shall be placed throughout the taper and along side the adjacent work area where the closure time exceeds 14 days. The edge line shall be yellow for left lane closures.

- (2) Standard 701501. When Standard 701501 is specified on two-lane/two-way roadways, construction operations shall be confined to one traffic lane leaving the opposite lane open to traffic.
- (3) Standard 701606. When Standard 701606 is specified reflective pavement markings shall be used when the closure time exceeds four days. The double yellow centerline shall be used in the two-way traffic area in addition to the barricades or drums. Single yellow left edge line shall be used to outline the barricade island. White right edge line shall be used along the barricades delineating the work area.
- (4) Standard 701801. On Standard 701801, where a temporary walkway encroaches on an existing parking lane, the lane shall be closed with cones, barricades, or drums.

Where a temporary walkway encroaches on a traveled lane, the lane shall be closed according to Standards 701501, 701606, or 701601.

All walkways shall be clearly identified, protected from motor vehicle traffic and free of any obstructions and hazards, such as holes, debris, construction equipment, and stored materials.

All hazards near or adjacent to walkways shall be clearly delineated.

When barricades are impractical to use or do not provide enough protection, orange safety fence shall be used to close off an area, with the approval of the Engineer.

- (k) Standard 701451. Only one interchange at a time may have ramps closed and only one exit ramp and one entrance ramp may be closed at a time.

701.19 Method of Measurement. This work will be measured for payment as follows.

- (a) Not Measured. Traffic control and protection required under Standards 701001, 701006, 701011, 701101, 701106, 701301, 701311, 701400, 701426, and 701427 will not be measured for payment.
- (b) Standards 701401, 701422, and 701446 will be measured for payment on an each basis only when the traffic control and protection applies to isolated stationary work areas and does not involve or is not a part of other protected areas.

Where the contract work to be performed requires longitudinal movement of the work area, each subsequent installation of a Standard in a new location will be paid for according to Article 109.04. A contiguous lateral movement of the work area causing a change in the location of traffic control devices, but not a longitudinal relocation of the work area, will not be considered a new location or installation.

- (c) Measured As Lump Sum. Traffic control and protection required under Standards 701201, 701206, 701306, 701326, 701336, 701406, 701421, 701451, 701456, 701501, 701502, 701601, 701602, 701606, 701701 and 701801 will be measured for payment on a lump sum basis. Traffic control and protection required under Standards 701401, 701422, and 701446 will be measured for payment on a lump sum basis, except as specified under Article 701.19(b). Where the Contractor's operations result in daily changing, or two or more work areas each of which requires traffic control according to one of the above Standards, each work area installation will not be paid for separately, but shall be included in the lump sum price for the type of protection furnished.
- (d) Traffic Control Surveillance will be measured on a calendar day basis.
- (e) Temporary rumble strips will be measured as each, where each is defined as a 25 ft (8 m) length installation.
- (f) Removal of existing pavement markings and raised reflective pavement markers will be measured for payment according to Article 783.05.

701.20 Basis of Payment. This work will be paid for as follows.

- (a) Traffic control and protection will be paid for at the contract unit price per each for TRAFFIC CONTROL AND PROTECTION STANDARD 701316, TRAFFIC CONTROL AND PROTECTION STANDARD 701321, TRAFFIC CONTROL AND PROTECTION STANDARD 701331, TRAFFIC CONTROL AND PROTECTION STANDARD 701401, TRAFFIC CONTROL AND PROTECTION STANDARD 701402, TRAFFIC CONTROL AND PROTECTION STANDARD 701411, TRAFFIC CONTROL AND PROTECTION STANDARD 701416, TRAFFIC CONTROL AND PROTECTION STANDARD 701422, TRAFFIC CONTROL AND

PROTECTION STANDARD 701423, TRAFFIC CONTROL AND PROTECTION STANDARD 701431, or TRAFFIC CONTROL AND PROTECTION STANDARD 701446, at the location specified.

The replacement of any temporary pavement marking which has been in place for seven days or more will be paid for according to Article 109.04.

In the event the total value of the work items for which a traffic control Standard is required is increased or decreased by more than ten percent, the unit price bid for that Standard will be adjusted as follows.

$$\text{Adjusted unit price} = 0.25P + 0.75P (1 \pm (X - 0.1))$$

Where: P is the bid unit price for the Standard

$$\text{Where: } X = \left| \frac{\text{Difference between original and final value of work}}{\text{Original value of work requiring the use of the Standard}} \right|$$

And where: $(X - 0.1) = 0$ if X is less than 0.1

The value of the work items used in calculating the increase or decrease will include only items which have been added to or deducted from the contract under Article 104.02 and only items which require use of the Standard.

When the plans require multiple locations for the Standard and the Method of Measurement is on an each basis, the adjustment shall only be applied to the location(s) where added work is required.

- (b) Traffic control and protection indicated in Article 701.19(c) will be paid for at the contract lump sum price for TRAFFIC CONTROL AND PROTECTION STANDARD 701201; TRAFFIC CONTROL AND PROTECTION STANDARD 701206; TRAFFIC CONTROL AND PROTECTION STANDARD 701306; TRAFFIC CONTROL AND PROTECTION STANDARD 701326; TRAFFIC CONTROL AND PROTECTION STANDARD 701336; TRAFFIC CONTROL AND PROTECTION STANDARD 701401; TRAFFIC CONTROL AND PROTECTION STANDARD 701406; TRAFFIC CONTROL AND PROTECTION STANDARD 701421; TRAFFIC CONTROL AND PROTECTION STANDARD 701422; TRAFFIC CONTROL AND PROTECTION STANDARD 701446; TRAFFIC CONTROL AND PROTECTION STANDARD 701451; TRAFFIC CONTROL AND PROTECTION STANDARD 701456; TRAFFIC CONTROL AND PROTECTION STANDARD 701501; TRAFFIC CONTROL AND PROTECTION STANDARD 701502; TRAFFIC CONTROL AND PROTECTION STANDARD 701601; TRAFFIC CONTROL AND PROTECTION STANDARD 701602; TRAFFIC CONTROL AND PROTECTION STANDARD 701606; TRAFFIC CONTROL AND PROTECTION STANDARD 701701; or TRAFFIC CONTROL AND PROTECTION STANDARD 701801.

Any alterations (additional or replacement of temporary pavement markings, or increases or decreases in work items by more than ten percent for which

a traffic control standard is required) will be paid for according to Article 701.20(a).

- (c) Temporary signals required for Standards 701316 and 701321 will be paid for separately at the contract unit price per each for TEMPORARY BRIDGE TRAFFIC SIGNALS.

When the Department furnishes the controller for Standards 701316 or 701321 the temporary bridge traffic signals will be paid for at the contract unit price per each for TEMPORARY BRIDGE TRAFFIC SIGNALS (STATE FURNISHED CONTROLLER).

- (d) Temporary concrete barrier will be measured and paid for according to Section 704.
- (e) Temporary impact attenuators and temporary bridge rail will be paid for separately.
- (f) Temporary rumble strips will be paid for at the contract unit price per each for TEMPORARY RUMBLE STRIPS.
- (g) Traffic Control Surveillance will be paid for at the contract unit price per calendar day or fraction thereof for TRAFFIC CONTROL SURVEILLANCE.
- (h) When portable changeable message signs are shown on the Standard, this work will not be paid for separately but shall be considered as included in the cost of the Standard.

For all other portable changeable message signs, this work will be paid for at the contract unit price per calendar month for each sign as CHANGEABLE MESSAGE SIGN.

- (i) Should the Engineer require additional signs, flaggers, barricades, or other traffic control devices over and above those specified, they will be paid for according to Article 109.04.

When the Contractor requests a change in the traffic control, any additional flaggers required will be at no additional cost to the Department.

- (j) Removal of existing pavement markings and raised reflective pavement markers will be paid for according to Article 783.06.

SECTION 702. NIGHTTIME WORK ZONE LIGHTING

702.01 Description. This work shall consist of furnishing, installing, maintaining, moving, and removing lighting for nighttime work zones. Nighttime shall be defined as occurring shortly before sunset until after sunrise.

702.02 Materials. The lighting shall consist of mobile and/or stationary lighting systems as required herein for the specific type of construction. Mobile lighting systems shall consist of luminaires attached to construction equipment or moveable carts. Stationary lighting systems shall consist of roadway luminaires mounted on temporary poles or trailer mounted light towers at fixed locations. Some lighting systems, such as balloon lights, may be adapted to both mobile and stationary applications.

702.03 Equipment. The Contractor shall furnish an illuminance meter for use by the Engineer. The meter shall have a digital display calibrated to NIST standards, shall be cosine and color corrected, and shall have an accuracy of \pm five percent. The sensor shall have a level indicator to ensure measurements are taken in a horizontal plane.

CONSTRUCTION REQUIREMENTS

702.04 General. At the preconstruction conference, the Contractor shall submit the type(s) of lighting system to be used and the locations of all devices.

Before nighttime construction may begin, the lighting system shall be demonstrated as being operational.

702.05 Nighttime Flagging. The requirements for nighttime flagging shall be according to Article 701.13 and the glare control requirements contained herein.

702.06 Lighting System Design. The lighting system shall be designed to meet the following.

- (a) **Lighting Levels.** The lighting system shall provide a minimum of 5 foot candles (54 lux) throughout the work area. For mobile operations, the work area shall be defined as 25 ft (9 m) in front of and behind moving equipment. For stationary operations, the work area shall be defined as the entire area where work is being performed.

Lighting levels will be measured with an illuminance meter. Readings will be taken in a horizontal plane 3 ft (1 m) above the pavement or ground surface.

- (b) **Glare Control.** The lighting system shall be designed and operated so as to avoid glare that interferes with traffic, workers, or inspection personnel. Lighting systems with flood, spot, or stadium type luminaires shall be aimed downward at the work and rotated outward no greater than 30 degrees from nadir (straight down). Balloon lights shall be positioned at least 12 ft (3.6 m) above the roadway.

As a large component of glare, the headlights of construction vehicles and equipment shall not be operated within the work zone except as allowed for specific construction operations. Headlights shall never be used when facing oncoming traffic.

- (c) Light Trespass. The lighting system shall be designed to effectively light the work area without spilling over to adjoining property. When, in the opinion of the Engineer, the lighting is disturbing adjoining property, the Contractor shall modify the lighting arrangement or add hardware to shield the light trespass.

702.07 Construction Operations. The lighting design required above shall be provided at any location where construction equipment is operating or workers are present on foot. When multiple operations are being carried out simultaneously, lighting shall be provided at each separate work area.

The lighting requirements for specific construction operations shall be as follows.

- (a) Installation or Removal of Work Zone Traffic Control. The required lighting level shall be provided at each truck and piece of equipment used during the installation or removal of work zone traffic control. Headlights may be operated in the work zone.
- (b) Milling and Paving. The required lighting level shall be provided by mounting a minimum of one balloon light to each piece of mobile construction equipment used in the work zone. This would include milling machines, mechanical sweepers, material transfer devices, spreading and finishing machines, and rollers; but not include trucks used to transport materials and personnel or other vehicles that are continuously moving in and out of the work zone. The headlights of construction equipment shall not be operated within the work zone.
- (c) Patching. The required lighting level shall be provided at each patching location where work is being performed.
- (d) Pavement Marking and Raised Reflective Pavement Marker Removal/Installation. The striping truck and the attenuator/arrow board trucks may be operated by headlights alone; however, additional lighting may be necessary for the operator of the striping truck to perform the work.

For raised reflective pavement marker removal and installation and other pavement marking operations where workers are on foot, the required lighting level shall be provided at each truck and piece of equipment.

- (e) Layout, Testing, and Inspection. The required lighting level shall be provided for each active area of construction layout, material testing, and inspection. The work area shall be defined as 15 ft (7.6 m) in front and back of the individual(s) performing the tasks.

702.08 Basis of Payment. This work will be paid for at the contract lump sum price for NIGHTTIME WORK ZONE LIGHTING.

SECTION 703. WORK ZONE PAVEMENT MARKING

703.01 Description. This work shall consist of furnishing, installing, maintaining, and removing short term and temporary pavement markings.

703.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Pavement Marking Tape	1095.06
(b) Paint Pavement Markings	1095.02

CONSTRUCTION REQUIREMENTS

703.03 General. Short term pavement markings shall consist of abbreviated patterns for edge, lane, and centerline markings. Within a specified time limit, short term pavement markings shall either be resurfaced or replaced with the full pavement marking patterns indicated on the plans with either a temporary material paid for as temporary pavement marking or with permanent material. Within the conditions as specified, the Contractor may be required to place all or a part of the quantities shown on the plans for short term pavement markings and temporary pavement markings.

The surface to which the pavement marking is to be applied shall be clean and dry. Pavement marking tape shall be applied to the prepared surface according to the manufacturer's recommendations or by a method approved by the Engineer. Painted lines shall be installed according to Section 780, except hand-operated strippers may be used for all applications of short term and temporary pavement marking.

703.04 Short Term Pavement Markings. Before the lane is opened to traffic, appropriate short term pavement markings shall be installed between all lanes open to traffic. Centerline or lane line markings shall consist of an abbreviated pattern of single stripes 4 ft (1.2 m) in length and a minimum of 4 in. (100 mm) wide at a maximum spacing of 40 ft (12 m) between stripes. Centerlines on two-lane highways shall be yellow and lane lines separating two or more lanes of traffic moving in the same direction shall be white. Edge line markings shall consist of 4 ft (1.2 m) stripes on 100 ft (30 m) centers installed at approximately a 45 degree diagonal pointing in the direction of traffic. Edge line markings will only be required on multilane divided highways and other highways with a paved shoulder greater than 4 ft (1.2 m) wide. Markings on the final wearing surface shall be transversely offset from the permanent pavement marking location as directed by the Engineer. Markings shall be removed within five days after the permanent pavement markings are installed.

The short term pavement markings shall be replaced with the required full standard pavement markings consisting of either temporary or permanent pavement marking as soon as possible. Except as indicated below, temporary pavement marking or the permanent pavement markings shall be installed for no passing zones within three calendar days and for all other markings within 14 calendar days, respectively, after the completion of any intermediate or final surface treatment. This time restriction shall begin at the completion of each intermediate or final lift on resurfacing projects.

If the existing markings are obliterated by milling or any other surface treatment, the time restriction shall begin when the entire surface has been treated. These restrictions may be delayed by the Engineer whenever the Contractor cannot apply pavement markings due to unanticipated inclement weather (other than winter shutdown on the project), strike activities, or other circumstances beyond the Contractor's control as determined by the Engineer. In these cases, the required full standard temporary or permanent markings shall be installed as soon as construction activities are resumed. Prior to winter shutdown, standard edge lines, lane lines, centerlines, no passing zones, and any other necessary markings as determined by the Engineer shall be installed on any intermediate or final surface remaining open to traffic during the winter shutdown period.

703.05 Temporary Pavement Marking. When any intermediate course cannot be overlaid or if the final surface cannot be permanently marked within the time restrictions listed above, the full standard markings shall be installed with temporary pavement marking. The temporary markings shall be of the same color and dimensions as shown on the plans for the permanent markings, or as directed by the Engineer.

Type I or Type II marking tape or paint shall be used at the option of the Contractor, except paint shall not be applied to the final wearing surface unless authorized by the Engineer for late season applications where tape adhesion would be a problem. Type III marking tape shall be used on the final wearing surface when the temporary pavement marking will conflict with the permanent pavement marking such as on tapers, crossovers and lane shifts.

Except during winter shutdown periods, temporary pavement marking showing deterioration for any reason within seven days after placement, shall be replaced by the Contractor. Temporary pavement markings which are in conflict with subsequently established pavement markings, or which interfere with the permanent pavement markings, shall be removed. Marking tape or paint placed on the final wearing course shall be transversely offset from the permanent pavement marking planned location as directed by the Engineer. All remaining temporary pavement marking tape or paint shall be removed within five working days after placement of the permanent pavement marking. When edge lines or channelizing lines are required, they shall be continuous. When continuous sections of tape are used, they shall be cut completely through at intervals of approximately 25 ft (8 m).

Instead of pavement markings, no passing zones on two-lane and three-lane roads may be identified by either the pennant "NO PASSING ZONE" warning sign or both the "DO NOT PASS" and "PASS WITH CARE" regulatory signs in conjunction with short term markings for periods of time up to three calendar days after an intermediate or final lift is completed on resurfacing projects.

These signs may also be used in lieu of pavement markings on low volume roads until it is practical and possible to install the permanent pavement markings.

If, in the traffic control plan, the road is specified as low volume, it is exempt from the requirements regarding no passing zone pavement markings.

703.06 Method of Measurement. Short term pavement markings and temporary pavement markings of the various line widths will be measured for payment in feet (meters) in place and accepted. Double yellow lines will be measured as two separate lines.

The replacement of temporary pavement markings of the various line widths during winter shutdown periods will be measured for payment in feet (meters) as specified above, except only those pavement markings directed by the Engineer to be replaced will be measured for payment.

Letters and symbols used in conjunction with temporary pavement marking conforming to the sizes and dimensions specified will be measured for payment in square feet (square meters) according to the areas listed in Table 1, Section 780.

Short term and temporary pavement marking removal will be measured for payment in square feet (square meters).

703.07 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for SHORT TERM PAVEMENT MARKING or for TEMPORARY PAVEMENT MARKING of the line width specified, and at the contract unit price per square foot (square meter) for TEMPORARY PAVEMENT MARKING LETTERS AND SYMBOLS. Removal will be paid for at the contract unit price per square foot (square meter) for WORK ZONE PAVEMENT MARKING REMOVAL.

When temporary pavement marking is shown on the Standard, the cost of the temporary pavement marking will be included in the cost of the Standard.

When Pavement Marking Tape, Type III is specified in the contract other than on a Standard, the work will be paid for at the contract unit price per foot (meter) for PAVEMENT MARKING TAPE, TYPE III of the line width specified and at the contract unit price per square feet (square meter) for PAVEMENT MARKING TAPE, TYPE III - LETTERS AND SYMBOLS.

SECTION 704. TEMPORARY CONCRETE BARRIER

704.01 Description. This work shall consist of furnishing, placing, maintaining, relocating, and removing precast concrete barrier at temporary locations.

704.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Precast Temporary Concrete Barrier	1042
(b) Reinforcement Bars (Note 1)	1006.10(a)
(c) Connecting Pins and Anchoring Pins	1006.09
(d) Connecting Loop Bars (Note 2)	
(e) Packaged Rapid Hardening Mortar or Concrete	1018

Note 1. Reinforcement bars shall be Grade 60 (Grade 400).

Note 2. Connecting loop bars shall be smooth bars according to the requirements of ASTM A 36.

CONSTRUCTION REQUIREMENTS

704.03 General. Precast concrete barrier shall be the F shape as detailed on the plans.

704.04 Installation. The barriers shall be seated on bare, clean pavement or paved shoulder and pinned together in a smooth, continuous line at the exact locations provided by the Engineer. The barrier unit at each end of the installation shall be secured to the pavement or paved shoulder using six anchoring pins and protected with an impact attenuator as shown on the plans.

Barriers or attachments damaged during transportation or handling, or by traffic during the life of the installation, shall be repaired or replaced. The Engineer will be the sole judge in determining which units or attachments require repair or replacement.

The barriers shall be removed when no longer required by the contract. After removal, all anchoring holes in the pavement or paved shoulder shall be filled with a rapid hardening mortar or concrete. Only enough water to permit placement and consolidation by rodding shall be used and the material shall be struck-off flush.

704.05 Method of Measurement. This work will be measured for payment in feet (meters) in place along the centerline of the barrier. When the barrier is relocated within the limits of the jobsite, the relocated barrier will be measured for payment in feet (meters) in place along the centerline of the barrier.

704.06 Basis of Payment. When the Contractor furnishes the barrier, this work will be paid for at the contract unit price per foot (meter) for TEMPORARY CONCRETE BARRIER or RELOCATE TEMPORARY CONCRETE BARRIER.

When the Department furnishes the barrier, this work will be paid for at the contract unit price per foot (meter) for TEMPORARY CONCRETE BARRIER, STATE OWNED; or RELOCATE TEMPORARY CONCRETE BARRIER, STATE OWNED.

Impact attenuators will be paid for separately.

SECTION 705. TEMPORARY STEEL PLATE BEAM GUARDRAIL

705.01 Description. This work shall consist of furnishing, erecting, maintaining, and removing steel plate beam guardrail, including posts and traffic barrier terminals.

705.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Steel Plate Beam Guardrail	1006.25
(b) Wood Posts and Wood Blockouts	1007.01, 1007.02, 1007.06
(c) Steel Posts, Blockouts, Restraints, and Wire Rope for Guardrail	1006.23
(d) Preservative Treatment	1007.12
(e) Hollow Structural Tubing	1006.27(b)

CONSTRUCTION REQUIREMENTS

705.03 General. Construction of the temporary steel plate beam guardrail and temporary traffic barrier terminals shall be according to the applicable requirements of Sections 630 and 631, respectively.

The guardrail shall be removed after use and shall become the property of the Contractor.

705.04 Method of Measurement. Temporary steel plate beam guardrail will be measured for payment in feet (meters). The length measured will be the overall length of rail erected, measured along the top edge of the rail elements to the limits shown on the plans.

The various types of temporary traffic barrier terminals will be measured for payment complete in place in units of each. The pay limit between the terminal and the adjacent guardrail shall be as shown on the plans.

705.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for TEMPORARY STEEL PLATE BEAM GUARDRAIL of the type specified and at the contract unit price per each for TEMPORARY TRAFFIC BARRIER TERMINAL, of the type specified.

SIGNING

SECTION 720. SIGN PANELS AND APPURTENANCES

720.01 Description. This work shall consist of furnishing, fabricating, and/or installing sign panels, complete with sign faces, legend, and supplemental panels.

720.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Sign Base	1090
(b) Sign Face, Sign Legend and Supplemental Panels	1091

The sign mounting support channel shall be manufactured from steel or aluminum.

Steel support channels shall be according to ASTM A 525 (mild strip) and Standard 720001 and shall be galvanized. Galvanizing shall be according to ASTM A 525, Coating Designation 90 when galvanized before forming and AASHTO M 232, Class B 2 when galvanized after forming.

Aluminum support channels shall be according to ASTM B 308M, Alloy 6061-T6 or ASTM B 221M, Alloy 6063-T6.

The stainless steel banding for mounting signs or sign support channels to light or signal standards shall be according to ASTM A 167 Type 302B, Grade 18-8 stainless steel.

720.03 General. The three types of individual panels are defined by surface area according to the following descriptions:

Type 1 – 9 sq ft (0.84 sq m) or less

Type 2 – Over 9 sq ft (0.84 sq m) and less than 24 sq ft (2.2 sq m)

Type 3 – 24 sq ft (2.2 sq m) or more

The surface area is determined by calculating the area of the smallest rectangle, measured from edge-to-edge (horizontally and vertically), that will circumscribe an individual sign, except in the case of a triangular sign. The area of a triangular sign shall be the net triangular area.

A sign panel assembly is composed of one or more sign panels mounted individually or as a group. The two types of sign panel assemblies are defined by the total surface area of the individual sign panels according to the following descriptions:

Type A assemblies are composed of Type 1 sign panels with a total sign panel area of 9 sq ft (0.84 sq m) or less.

Type B assemblies are composed of Type 1 or Type 2 sign panels with a total sign panel area over 9 sq ft (0.84 sq m).

Where any sign legend dimensions shown in the plans conflict with the sign legend manufacturer's recommendations, the dimensions shown in the plans or as determined by the Engineer shall govern.

The backs of all sign panels shall be metal stamped, engraved, etched, decal, or otherwise marked in a manner designed to last as long as the sign face material, in letters and numerals at least 3/8 in. (9.5 mm) but no more than 3/4 in. (19 mm) in height with the month and year of manufacture, the name of the sign manufacturer, and the initials IDOT.

When standard signs designated by letters and numbers are to be furnished, they shall be according to the MUTCD. Detailed drawings of signs with an "I" preceding the sign designation code are available from the Engineer of Operations. Detailed drawings of all other standard signs are available from the Federal Highway Administration (HTO-20), Washington, D.C. 20590.

CONSTRUCTION REQUIREMENTS

720.04 Installation. Sign panels shall be installed using all required supporting channels and mounting hardware specified.

All sheet aluminum sign panels and supporting panels shall be mounted to the sign posts or supporting channels with 5/16 in. (M8) stainless steel, zinc, or cadmium

plated steel hex head bolts with lock nuts. For design panels 9 sq ft (0.84 sq m) or greater in area, flat steel fender washers shall be placed next to the bolt head and the nut. A 1/8 in. (3 mm) thick nylon washer shall be placed between the metal washer and the sign face. For sign panels less than 9 sq ft (0.84 sq m) in area, standard steel flat washer shall be placed next to the bolt head and nut. A nylon washer shall be placed between the metal washer and the sign face.

Supporting channels shall be used to brace sign panels mounted permanently on:

- (a) Single posts when the sign width is greater than 36 in. (900 mm).
- (b) More than one post when the distance between the posts is greater than 4 ft (1.2 m).

Horizontal supporting channels used to brace individual signs shall be located using the mounting holes prepunched in the sign blank.

All bolts and nuts shall have National Coarse Thread (UNC).

When a Type 2 panel is to be installed above or below a Type 3 panel, all materials shall be the same as those used for the Type 3 panel. The Contractor shall use the same type of sign base material and sign legend throughout this work.

When the plans require auxiliary sign panels or route shields to be installed on a Type 3 sign panel, they shall be fabricated using a sign base according to Article 1090.01 and a sign face according to Article 1091.01.

720.05 Method of Measurement. Sign panels will be measured for payment in square feet (square meters) according to Article 720.03.

720.06 Basis of Payment. This work will be paid for at the contract unit price per square foot (square meter) for SIGN PANEL, of the type specified.

SECTION 721. SIGN PANEL OVERLAY

721.01 Description. This work shall consist of furnishing, and installing sign panel overlays, complete with reflectorized or nonreflectorized sign face and legend, on existing sign panels.

721.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Sign Base	1090
(b) Sign Face (Note 1)	1091
(c) Sign Legends (Note 2)	1091
(d) Overlay Panels (Note 3)	1090.02

Note 1. The sign face shall be Type A.

Note 2. The legend shall be Type A, except when black in color.

Note 3. The overlay panels shall be 0.08 in. (2 mm) thick.

CONSTRUCTION REQUIREMENTS

721.03 General. The existing sign shall be stripped of the sign legend, and the sign panel overlay and new legend shall be installed on the existing sign base. Ground-mounted sign panels may be taken down or the required work may be done in place. Any sign panel which is removed for overlaying shall be rigidly braced on the backside so the panel shall not flex and damage the overlay while being reinstalled. Sign panel hardware broken during removal of a sign panel shall be replaced.

The existing legend shall be completely removed, leaving no rivets protruding from the surface of the panel. The overlay shall be applied in vertical panels not more than 48 in. (1200 mm) nor less than 24 in. (600 mm) in width.

Adjacent panels shall be butt-joined with the spaces between joints 0.10 in. (2.5 mm) or less in width. No horizontal joints shall be used, except on sign panels over 12 ft (3.6 m) in height.

The panels shall be securely fastened to the sign with 3/16 in. (4.75 mm) aluminum dome head rivets with aluminum mandrels. All rivets shall be matched to the color of the overlay panel being installed. The rivets shall be placed at 12 in. (300 mm) centers or less along all four edges and in a vertical row down the center of the panel at 24 in. (600 mm) centers or less. The rivets shall be approximately 1/4 in. (6 mm) in from open edges. All rivets shall be placed in the area of the aluminum extrusion panel ridge to prevent dimples in the sign panel overlay.

The sign sizes and legend sizes shown in the plans shall be verified in the field by the Contractor. The replacement legend shall be the same size and shall be spaced the same as the existing sign. The Contractor shall be responsible for the correct spacing of any revised legend according to the general freeway signing practices.

Individual signs shall not be out of service for longer than 24 consecutive hours, subject to the following conditions and exceptions.

- (a) No more than one advance guide sign of the sequence of signs on an approach to an interchange shall be out of service at any given time. (These signs are labeled "A" in the plans.)
- (b) Signs labeled "B" may be out of service at the same time as any other signs.
- (c) Signs labeled "C" are considered critical and shall be out of service no more than six consecutive hours and shall not be out of service when any "A" sign for the approach is also out of service.

721.04 Method of Measurement. The sign panel overlay will be measured for payment in square feet (square meters). The area used for measurement shall be the actual area of the sign panel overlay.

721.05 Basis of Payment. This work will be paid for at the contract unit price per square foot (square meters) for SIGN PANEL OVERLAY.

SECTION 722. DEMOUNTABLE SIGN LEGEND CHARACTERS AND ARROWS

722.01 Description. This work shall consist of furnishing demountable legend characters, arrows, symbols, and route shields and installing them on existing sign panels.

722.02 Materials. Materials shall be according to Article 1091.02 for sign legend specified for Type 3 sign panels.

CONSTRUCTION REQUIREMENTS

722.03 General. Each demountable legend unit shall be securely fastened to a previously prepared sign panel.

722.04 Basis of Payment. Demountable sign legend characters, arrows, symbols, and route shields will be paid for at the contract unit price per each for DEMOUNTABLE LEGEND CHARACTERS AND ARROWS. Borders, diagonals, periods, commas, hyphens, and apostrophes will not be paid for separately.

Auxiliary panels will be paid for according to Article 721.05.

SECTION 723. INSTALL EXISTING SIGN PANEL

723.01 Description. This work shall consist of installing an existing sign panel on a previously erected sign support(s) or sign structure.

CONSTRUCTION REQUIREMENTS

723.02 General. The existing sign panel shall be transported by the Contractor to the location specified in the contract and installed on the previously erected sign support(s) or sign structure according to the details shown in the plans or as directed by the Engineer.

723.03 Method of Measurement. This work will be measured for payment in square feet (square meters) according to Article 720.03.

723.04 Basis of Payment. This work will be paid for at the contract unit price per square foot (square meter) for INSTALL EXISTING SIGN PANEL.

SECTION 724. REMOVE AND RELOCATE SIGN PANEL AND SIGN PANEL ASSEMBLY

724.01 Description. This work shall consist of removing and relocating sign panels and sign panel assemblies with their supports.

724.02 Backfill. All holes left from the removal of supports shall be backfilled with suitable material approved by the Engineer. The surface of the filled hole shall be treated to match the surrounding area.

724.03 Removal. Removal shall be as follows.

- (a) Sign Panel Assembly. The sign panel assembly shall be removed from the posts, the supporting channels and the entire support(s) shall be completely removed, and all items transported to the location specified in the contract. When the existing sign panel assembly to be removed is to be replaced by a new sign panel assembly, the new assembly shall be completely installed prior to removal of the existing assembly. Duplicate assemblies shall not exist for periods in excess of 24 hours
- (b) Sign Panels. The sign panel shall be removed completely, including all hardware, and transported to the location specified in the contract.

724.04 Relocate. Relocation of sign panel assemblies and sign panels shall be as follows.

- (a) Sign Panel Assembly. The sign panel assembly and supporting channels shall be installed or reinstalled on new sign supports using new mounting hardware according to the details shown in the plans. In no case shall the time between the removal of an existing sign panel assembly and its reinstallation be in excess of 45 minutes.
- (b) Sign Panel. The sign panel shall be installed or reinstalled on previously erected sign supports or a sign structure using new mounting hardware according to the details shown in the plans or as directed by the Engineer. Any new sign support brackets or redrilling of existing brackets shall be provided when necessary. In no case shall the time between the removal of an existing sign panel and its reinstallation be in excess of two hours, unless authorized in writing by the Engineer.

724.05 State Furnished Signs. When signs are specified to be furnished on the project by the State, the signs will be made available to the Contractor's office upon written request. These signs will be delivered within one week of request and, upon delivery, will become the responsibility of the Contractor.

724.06 Method of Measurement. Sign Panel removal and relocating will be measured for payment in square feet (square meters) according to Article 720.03.

724.07 Basis of Payment. This work will be paid for at the contract unit price per each for REMOVE SIGN PANEL ASSEMBLY, of the type specified; and RELOCATE SIGN PANEL ASSEMBLY, of the type specified; and at the contract unit

price per square foot (square meter) for REMOVE SIGN PANEL, of the type specified; and RELOCATE SIGN PANEL, of the type specified.

SECTION 725. OBJECT MARKER

725.01 Description. This work shall consist of furnishing and installing an object marker Type 1, Type 2, or Type 3 on a previously erected support.

725.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Acrylic Plastic Prismatic Center-Mount Reflectors (Note 1)	1097.03
(b) Sign Base	1090
(c) Sign Face	1091

Note 1. Used on Type 1 or Type 2 object markers.

725.03 Basis of Payment. This work will be paid for at the contract unit price per each for OBJECT MARKER - TYPE 1, TYPE 2, or TYPE 3.

SECTION 726. MILE POST MARKER ASSEMBLY

726.01 Description. This work shall consist of furnishing and installing a milepost marker at the location specified in the plans.

726.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Sign Legend, Type 1	1091
(b) Metal Posts and Hardware for Highway Markers, Signs, and Delineators	1006.29
(c) Sign Face	1091

726.03 Basis of Payment. This work will be paid for at the contract unit price per each for MILE POST MARKER ASSEMBLY.

SECTION 727. SIGN SUPPORT – BREAKAWAY

727.01 Description. This work shall consist of furnishing and installing galvanized structural steel breakaway sign supports or galvanized hollow structural steel tubular breakaway sign supports and stub posts.

727.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Structural Steel	1006.04
(b) Structural Steel Supports	1093.01
(c) High Strength Steel Bolts, Nuts and Washers	1006.08(b)

Hollow structural steel tubing shall be according to ASTM A 500 (Grade B) or ASTM A 501.

All other structural steel shapes and plates shall be according to AASHTO M 270 (M 270M).

Shims shall be fabricated from stainless steel shim stock according to ASTM A 240 (A 240M), Type 302 or 304.

CONSTRUCTION REQUIREMENTS

727.03 General. Sign locations shall be staked by the Contractor and approved by the Engineer prior to installation of sign supports and structures.

The Contractor and the Engineer together shall determine the exact lengths required before ordering the supports to be fabricated.

Breakaway sign posts and breakaway tubular sign posts shall be according to the plans, and the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

The steel sign supports shall be fabricated and inspected according to Articles 505.03 through 505.05.

All fabrication shall be completed and ready for assembly before galvanizing. No punching or drilling shall be permitted after galvanizing.

The slot and 5/8 in. (16 mm) diameter hole in the web and the fuse plate bolt holes in the flange shall be made before galvanizing. The post flange shall be saw cut after galvanizing and bare metal surfaces shall be coated with an approved zinc solder or zinc-rich paint. These surfaces shall not be coated until the fuse plate is installed and all bolts fully tightened.

After fabrication, the post, fuse plate, base plate, and upper 6 in. (150 mm) minimum of the stub post shall be galvanized by the hot-dip process according to AASHTO M 111.

The sign supports shall be erected in a vertical position on stub posts previously cast into the foundations. The faces of the supports shall be flush with the sign throughout the contact area. The supports shall be plumbed and brought to final grade.

The top of the supports shall be set within 2 in. (50 mm) of, but not above, the top of the sign when installed at the height specified. When two or more sign supports are required for any sign, the supports shall be erected parallel to each other.

Shims may be used between the plates to level posts.

Posts shall be assembled to stubs with high strength bolts and washers as detailed on the plans.

The bolts in the base plate shall be tightened in a systematic order to the required torque.

Each bolt shall be loosened and tightened to the required torque in the same order as the initial tightening.

Threads at the junction of the bolt and nut shall be burred or center punched to prevent the nut from loosening.

727.04 Welding. All welding shall be continuous and according to Article 505.04(q).

727.05 Tightening. All friction fuse bolts shall be tightened in the shop as approved by the Engineer and according to the current Specifications of Structural Joints using AASHTO M 164 (M 164M) bolts and one of the following methods.

- (1) Turn-of-Nut Tightening
- (2) Tightening by use of a Direct Tension Indicator

Tightening shall obtain the following minimum residual tension on each bolt.

Min. Residual Bolt Tension		Min. Residual Bolt Tension	
Bolt Dia.	lb (kN)	Bolt Dia.	lb (kN)
1/2 in. (M12)	12,050 (54)	7/8 in. (M22)	39,250 (175)
5/8 in. (M16)	19,200 (85)	1 in. (M24)	51,500 (229)
3/4 in. (M20)	28,400 (126)	1 1/8 in. (M27)	56,450 (251)
		1 1/4 in. (M30)	71,700 (319)

727.06 Foundations. Sign support foundations shall be cast-in-place according to Section 503.

727.07 Method of Measurement. This work will be measured for payment in pounds (kilograms) of structural steel sign support erected in place.

The measurement of the structural steel shall be computed on the basis of the weight (mass) per foot (meter) of the support, multiplied by the combined length of the main posts and stub posts.

The measurement of the tubular steel shall be computed on the basis of the Post Weight (Mass) Calibration Table shown on the plans for the main posts installed, plus the weight (mass) of the stub posts.

No allowance will be made for the weight (mass) of the welds, either shop or field, and for the galvanizing. No deduction will be made for cuts, copes, or holes.

727.08 Basis of Payment. This work will be paid for at the contract unit price per pound (kilogram) for STRUCTURAL STEEL SIGN SUPPORT-BREAKAWAY or TUBULAR STEEL SIGN SUPPORT-BREAKAWAY.

Concrete foundations will be paid for according to Article 734.05

SECTION 728. TELESCOPING STEEL SIGN SUPPORT

728.01 Description. This work shall consist of furnishing and installing telescoping steel sign supports for ground-mounted signs utilizing a telescoping base section or a previously installed cast iron base.

728.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Structural Steel Supports, Telescoping	1093.01(c)

CONSTRUCTION REQUIREMENTS

728.03 General. The estimated length of a support includes the total length of all required sections. When two or more posts support the same sign, they shall be erected parallel to each other with the tops of the posts at the same elevation.

The sign locations shall be staked by the Contractor and approved by the Engineer prior to installation of the posts. The Contractor shall be responsible for the proper elevation, offset, and orientation of all signs as indicated in the plans or as directed by the Engineer.

When the support specified is too long, the Contractor may choose to cut the top section or telescope the top section farther into the base section. Any section cut shall have the cut end completely deburred.

When signs are to be placed on adjacent post sides and the posts have holes in only two opposite sides, the Contractor shall drill any additional holes necessary to the tolerances according to Article 1093.01(c).

The top section may be spliced. Splicing shall be done according to the plans and will only be permitted in the upper third of the top section. Only one splice per support will be permitted. The internal splice member shall be 1 3/4 x 1 3/4 in. (45 x 45 mm).

728.04 Installation Methods. Installation methods shall be as follows.

- (a) **Pavement Mount.** Pavement mounted installation shall be used only in paved areas and shall consist of three sections as shown in the plans. The base sections may be installed before or after the paving operation, except a hole no greater than 6 in. (150 mm) in diameter shall be cut in the pavement.

Any pavement removed shall be neatly replaced around the base section with like material to the depth of the original pavement.

The 2 1/4 x 2 1/4 in. (57 x 57 mm) base section shall be driven by hand or mechanical means to a minimum depth of 34 in. (850 mm) measured from the pavement surface. The top of the base section shall be protected by a

suitable driving cap. When required by the Engineer, the earth around the support shall be compacted after driving.

The sleeve section shall be telescoped over the base section or may be driven with the base section as a unit. The tops of both sections shall be at the same elevation, with the bolt holes aligned.

The 2 x 2 in. (50 x 50 mm) top section shall be telescoped into the base section a minimum of 8 in. (200 mm) and a maximum of 12 in. (300 mm) and the three sections fastened together as shown in the plans.

- (b) Ground Mount. Ground mounted installations shall consist of two sections as shown in the plans. The 2 1/4 x 2 1/4 in. (57 x 57 mm) base section shall be driven by hand or mechanical means to a minimum depth of 5 ft (1.5 m) measured from the ground line or as shown in the plans. The top of the base section shall be protected by a suitable driving cap. When required by the Engineer, the earth around the support shall be compacted after driving.

The 2 x 2 in. (50 x 50 mm) top section shall be telescoped into the base section a minimum of 8 in. (200 mm) and a maximum of 12 in. (300 mm) and the two sections fastened together as shown in the plans.

- (c) Base Casting. Base casting shall consist of two sections as shown in the plans. The base section shall be 2 1/4 x 2 1/4 x 8 1/2 in. (57 x 57 x 216 mm). This section shall be inserted at least 6 3/4 in. (170 mm) into the base casting to form a shim into which the 2 in. (50 mm) section is placed. The top section shall be inserted at least 6 3/4 in. (170 mm) into the base casting. After the top section is in place, the installation shall be bolted together as shown in the plans.

728.05 Method of Measurement. This work will be measured for payment in feet (meters). The length measured will be the total length of all sections installed, except for any internal splice members and any telescoping of a top section more than 12 in. (300 mm) into a base section.

728.06 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for TELESCOPING STEEL SIGN SUPPORT.

Payment for the base casting will be made according to Section 731.

SECTION 729. METAL POST

729.01 Description. This work shall consist of furnishing Type A and/or Type B metal posts, and installing them utilizing the direct burial method.

729.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Metal Post	1006.29

CONSTRUCTION REQUIREMENTS

729.03 General. The metal posts may be driven by hand or mechanical means to a minimum depth of 3.5 ft (1.0 m) for Type A or 4.0 ft (1.2 m) for Type B. The depths shall be measured from the ground line. The post shall be protected by a suitable driving cap and when required by the Engineer, the material around the post shall be compacted after driving.

Scratching, chipping, or other damage to the posts shall be avoided during handling and installation. If chips and/or scratches occur, the areas shall be recoated in the field by a method meeting the coating manufacturer's recommendations. Chips and scratches totaling more than five percent of the surface area of any one post and/or more than five percent of the surface area in any 1 ft (300 mm) segment of any one post shall be cause for rejection of the post.

When the post specified is too long, the Contractor may choose to cut the post to the required length or increase the embedment. Any post cut shall be installed with the cut end at the bottom.

729.04 Method of Measurement. The metal post will be measured for payment in feet (meters). The length to be measured shall be the total length installed as shown on the plans.

729.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for METAL POST - TYPE A or TYPE B.

SECTION 730. WOOD SIGN SUPPORT

730.01 Description. This work shall consist of furnishing and installing wood sign supports for ground-mounted signs.

730.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate	1004.05
(b) Wood Sign Support	1007.05

CONSTRUCTION REQUIREMENTS

730.03 General. The support shall be modified to satisfy the breakaway requirements by drilling 1 1/2 in. (38 mm) diameter holes centered at 4 and 18 in. (100 and 450 mm) above the groundline and perpendicular to the centerline of the roadway.

When the support is too long, the Contractor may choose to dig the hole deeper or to cut the support to the required length. All cut ends shall become the tops of the supports, and shall be treated with a mixture of not less than five percent pentachlorophenol and petroleum solvent before the signs are mounted.

730.04 Installation. The support shall be installed in a vertical hole not exceeding 12 in. (300 mm) in diameter, and not less than 5 ft (1.5 m) deep. The support shall be centered in the hole with the 6 in. (150 mm) dimension parallel to the adjacent edge of pavement. The hole shall then be backfilled with CA 6, thoroughly tamped in 12 in. (300 mm) lifts.

At least 14 days after placing the sign assembly on the post, the Contractor shall inspect each installation, straightening and retamping around each post as required.

730.05 Method of Measurement. This work will be measured for payment in feet (meters). The length to be measured will be the total length installed. Any embedment over 6 in. (150 mm) beyond that shown in the plans will not be included for measurement.

730.06 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for WOOD SIGN SUPPORT.

SECTION 731. BASE FOR TELESCOPING STEEL SIGN SUPPORT

731.01 Description. This work shall consist of furnishing and installing a base for a telescoping steel sign support.

731.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Base for Telescoping Sign Support	1093.02
(b) Hardware (Note 1)	1006.29(d)

Note 1. The anchor bolts, nuts, and washers shall be stainless steel.

731.03 Method of Measurement. Each base will be measured for payment as an individual unit complete in place.

731.04 Basis of Payment. This work will be paid for at the contract unit price per each for BASE FOR TELESCOPING STEEL SIGN SUPPORT.

SECTION 732. RESERVED

SECTION 733. OVERHEAD SIGN STRUCTURES

733.01 Description. This work shall consist of fabricating, furnishing, and erecting overhead sign structures, including supports, on previously prepared foundations.

733.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) High Strength Steel Bolts, Nuts, and Washers	1006.08(b)
(b) Fabric Bearing Pads	1082.01
(c) Overhead Sign Structures	1094

CONSTRUCTION REQUIREMENTS

733.03 Drawings. Two sets of shop fabrication drawings for each overhead sign structure shall be submitted to the Engineer for approval according to Article 505.03.

733.04 Fabrication. Structural steel shall be fabricated and inspected according to the applicable portions of Articles 505.04 and 505.05.

Aluminum shall be fabricated according to Article 1094.05 and the following. Thermal cutting will not be permitted. Holes and cuts in extruded alloys shall be made by mechanical methods (drilled, sawed, machined). All holes in castings or forgings shall be drilled from solid or formed and reamed for final fit. Damage to exposed aluminum surfaces producing an objectionable appearance, in the opinion of the Engineer, shall be cause for rejection. Cast or forged parts shall have all fins, flash, runner or riser remnants, or other irregularities removed. Tubing shall be seamless and uniform in quality and temper. Exterior and interior surfaces shall be clean, smooth, and free from slivers, laminations, cracks, or other defects.

733.05 Surface Treatment of Structural Steel Supports. Structural steel supports shall be hot dipped galvanized according to AASHTO M 111 after fabrication is completed.

733.06 Erection. Erection of all structural steel and structural aluminum shall be according to the applicable requirements of Article 505.08. High strength bolts, nuts, and washers shall be assembled and tightened according to Article 505.04(f)(2).

733.07 Wire Cloth. The void between the base plate and the foundation shall be enclosed according to the following requirements.

A stainless steel mesh 1/4 in. (6 mm) maximum opening with a minimum wire diameter of AWG No. 16 (1.5 mm) with a minimum 2 in. (50 mm) lap shall be installed to enclose the void between the base plate and the foundation. The stainless steel screen wire shall be formed to the shape of the base plate and fastened to the base plate with 3/4 in. (19 mm) stainless steel banding. The screen wire shall overlap and be fastened with a ring type connection.

733.08 Field Painting. Field painting for all exposed steel surfaces not galvanized shall be done according to the plans and the requirements of the latest paint system provisions for structural steel.

733.09 Method of Measurement. This work will be measured for payment as follows.

- (a) Sign Structure - Span, Monotube, Cantilever, or Butterfly. Span and monotube sign structures will be measured for payment in feet (meters) from center to center of supports. Cantilever and butterfly sign structures will be measured for payment in feet (meters) from end of the unsupported end(s) to center of the support as shown on the plans. Measurement will include the end supports. For steel or aluminum, three dimensional space frame trusses, measurement will include the truss inspection grating inside the truss.
- (b) Sign Structure - Bridge Mounted. Bridge mounted overhead sign structures will be measured for payment in feet (meters) of the overall length of the walkway.
- (c) Sign Structure Walkway. The sign structure walkway will be measured for payment in feet (meters) of the overall length of the walkway, end to end.

733.10 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for OVERHEAD SIGN STRUCTURE - SPAN, OVERHEAD SIGN STRUCTURE - CANTILEVER, OVERHEAD SIGN STRUCTURE - BUTTERFLY, OVERHEAD SIGN STRUCTURE - MONOTUBE, or OVERHEAD SIGN STRUCTURE - WALKWAY, of the type specified; or OVERHEAD SIGN STRUCTURE - BRIDGE MOUNTED.

SECTION 734. CONCRETE FOUNDATIONS FOR SIGN STRUCTURES

734.01 Description. This work shall consist of constructing a foundation for structural steel sign supports and overhead sign structures.

734.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Grounding Electrodes	1087.01(b)
(c) Anchor Rods	1094.02
(d) Reinforcement Bars	1006.10(a)

CONSTRUCTION REQUIREMENTS

734.03 Installation. Concrete foundations of the type and size specified in the plans, shall be constructed according to the applicable requirements of Section 503 and the following.

Grounding electrodes shall be installed according to Section 806.

The anchor rods shall be firmly held in position by a template during the placing of the concrete.

- (a) Spread Footing for Overhead Sign Structures. The footings shall be constructed according to the applicable requirements of Article 503.13. Conduit, when specified, shall be installed rigidly in place before the concrete is deposited. The top 4 in. (100 mm) of backfill material shall be topsoil suitable for seeding.

Backfill shall be placed around the footing prior to raising the structural steel support frames. It shall be placed in 4 in. (100 mm) lifts and shall be compacted to not less than 90 percent of the standard laboratory density according to AASHTO T 99 (Method C). Care shall be taken to prevent damage to the concrete. Backfill shall be brought level to the finished ground line. All areas disturbed by the Contractor's operations shall be seeded according to Section 250.

The top of the footing shall be finished level, and all exposed surfaces shall be finished according to Article 503.15(a).

- (b) Drilled Shaft Foundations for Overhead Sign Structures. Drilled shaft foundations shall be according to Section 516 and the following.

When obstructions are encountered, the Contractor shall request to relocate the foundation. Any abandoned holes shall be backfilled to the satisfaction of the Engineer.

- (c) Concrete Foundations for Ground-Mounted Sign Supports. The top segment of these foundations shall be finished according to Article 503.15(a) and formed down to a depth of at least 1 ft (300 mm) below the ground line, and the concrete shall be finished level at the ground line.

Concrete shall be cured before sign supports and overhead sign structures are installed.

734.04 Method of Measurement. This item will be measured for payment according to Article 503.21.

Excavation in rock will be measured for payment according to Article 502.12.

734.05 Basis of Payment. This work will be paid for at the contract unit price per cubic yard (cubic meter) for CONCRETE FOUNDATIONS, or DRILLED SHAFT CONCRETE FOUNDATIONS.

Excavation in rock will be paid for according to Article 502.13.

Obstruction mitigation or abandoned foundation excavations and backfill will be paid for according to Article 109.04.

SECTION 735. RELOCATE OVERHEAD SIGN STRUCTURE OR GROUND MOUNTED SIGN SUPPORT

735.01 Description. This work shall consist of removing a span, monotube or cantilever overhead sign structure complete with support(s) and/or a ground mounted sign support, and installing it at another location using either the existing supports or new supports.

735.02 Relocation. The new foundation shall be constructed according to Section 734, and the old foundation shall be removed according to Section 737.

- (a) Overhead Sign Structure. The complete horizontal section of the overhead sign structure shall be removed from the support(s) and the support(s) removed from the foundation(s). The complete overhead sign structure shall then be transported to its new location and erected according to Section 733, using new nuts and washers on the foundation(s).
- (b) Ground Mounted Sign Supports. Each support shall be removed from the foundation, transported to its new location, and erected on a foundation.

All materials required for erecting the relocated support, such as mounting hardware, shims, etc., shall be considered as part of the support.

735.03 Basis of Payment. This work will be paid for at the contract unit price per each for RELOCATE OVERHEAD SIGN STRUCTURE - SPAN or CANTILEVER, RELOCATE MONOTUBE OVERHEAD SIGN STRUCTURE - SPAN or CANTILEVER, or RELOCATE GROUND MOUNTED SIGN SUPPORT.

SECTION 736. REMOVE OVERHEAD SIGN STRUCTURE

736.01 Description. This work shall consist of removing a span, monotube, cantilever, or bridge-mounted overhead sign structure.

736.02 Removal. The entire overhead sign structure, including sign panels and sign lighting, is to be removed from the right-of-way. The removed structure shall be disposed of according to the contract.

Concrete foundations shall be removed according to Section 737.

736.03 Basis of Payment. This work will be paid for at the contract unit price per each for REMOVE OVERHEAD SIGN STRUCTURE - SPAN or CANTILEVER, REMOVE OVERHEAD SIGN STRUCTURE, MONOTUBE - SPAN or CANTILEVER, or REMOVE OVERHEAD SIGN STRUCTURE - BRIDGE MOUNTED.

SECTION 737. REMOVE GROUND MOUNTED SIGN SUPPORT AND/OR CONCRETE FOUNDATIONS

737.01 Description. This work shall consist of removing a ground-mounted sign support and/or concrete foundations.

737.02 Removal. Removal of ground mounted sign supports and/or concrete foundations shall be as follows.

- (a) Ground Mounted Sign Support. The ground mounted sign support is to be completely removed from the right-of-way within 24 hours after removal of the sign panel. The removed support shall become the property of the Contractor.

Sign panels shall be removed according to Section 724.

- (b) Concrete Foundations. All components of the concrete foundation, including the concrete, reinforcing, stub post, and electrical items, shall be removed at least 1 ft (300 mm) below the ground line.

The use of explosives of any kind will not be permitted in removing concrete foundations.

The hole shall be backfilled with suitable material approved by the Engineer. The surface of the filled hole shall be treated to match the surrounding area.

All debris resulting from this operation shall be removed from the right-of-way.

Concrete foundations for overhead sign structures shall be removed within five calendar days after the removal of the overhead sign structure.

737.03 Basis of Payment. This work will be paid for at the contract unit price per each for REMOVE GROUND MOUNTED SIGN SUPPORT and/or REMOVE CONCRETE FOUNDATION - GROUND MOUNT or OVERHEAD.

SECTION 738. REMOVE, REPLACE, AND REERECT OVERHEAD SIGN STRUCTURE - SPAN, MONOTUBE, OR CANTILEVER

738.01 Description. This work shall consist of removing a sign structure, replacing damaged components, and reerecting the overhead sign structure.

738.02 Materials. Drawings, fabrication, welding of structural steel, surface treatment of structural steel supports, erection, wire cloth, galvanizing and the replacement of nuts, bolts, and washers shall be according to the applicable portions of Section 733.

738.03 Removal. Removal of structural steel supports and/or overhead sign structures shall be as follows.

- (a) **Structural Steel Support.** The damaged structural steel end support shall be removed, replaced, and moved from the right-of-way. The support shall become the property of the Contractor. Any salvage value shall be reflected in the bid price. This work shall also include the removal of an existing sign panel, if one is present, and reinstallation of the same sign panel on the new end support, and the installation of a sign structure number as directed by the Engineer.

- (b) **Overhead Sign Structure.** The Contractor shall remove the entire overhead sign structure, including sign panels, sign lighting, or walkway from its support(s) and properly anchor the structure on blocks. The entire overhead sign structure shall be reerected when the structure is reattached to the supports including the replacement of any damaged hardware.

Saddle shim blocks and fabric pads shall remain in their proper position during reerection.

The district where this work is being performed shall be responsible for disconnecting the sign lighting prior to removal of the overhead structure and reconnecting the sign lighting after the overhead structure has been reerected.

738.04 Basis of Payment. This work will be paid for at the contract unit price per each for STRUCTURAL STEEL SUPPORT FOR OVERHEAD SIGN STRUCTURE - SPAN or CANTILEVER. Removing and reerecting the overhead sign structure will be paid at the contract unit price per each for REMOVE AND REERECT OVERHEAD SIGN STRUCTURE-SPAN or CANTILEVER.

PAVEMENT MARKING

SECTION 780. PAVEMENT STRIPING

780.01 Description. This work shall consist of furnishing and applying pavement marking.

780.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Thermoplastic Pavement Markings	1095.01
(b) Paint Pavement Markings	1095.02
(c) Preformed Plastic Pavement Markings	1095.03
(d) Epoxy Pavement Marking	1095.04
(e) Preformed Thermoplastic Pavement Marking	1095.05
(f) Glass Beads for Pavement Markings	1095.07
(g) Polyurea Pavement Marking	1095.08

780.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Thermoplastic Truck-Mounted (Note 1)	1105.01(a)
(b) Thermoplastic Hand-Operated (Note 1)	1105.01(b)
(c) Epoxy	1105.02
(d) Polyurea	1105.03

Note 1. A mechanical beader approved by the Engineer shall be used.

CONSTRUCTION REQUIREMENTS

780.04 General. Thermoplastic, epoxy, and polyurea pavement markings shall only be applied by Contractors on the list of approved Contractors maintained by the Engineer of Operations and in effect on the date of advertisement for bids.

Pavement marking on freeways shall be placed with truck-mounted equipment. Markings on roads other than freeways may be placed with either truck-mounted or hand-operated equipment.

Before applying the pavement marking material, the pavement shall be clean, dry, and free of debris or any other material that would reduce the adhesion of the markings on the pavement.

The edge of a center line or lane line shall be offset a minimum distance of 2 in. (50 mm) from a longitudinal crack or joint. Edge lines shall be approximately 2 in. (50 mm) from the edge of pavement. The finished center and lane lines shall be straight, with the lateral deviation of any 10 ft (3 m) line 1 in. (25 mm) or less.

Pavement marking words and symbols shall conform closely to the dimensions and spacing specified in the MUTCD and the plans. Deviations from the required dimensions and spacing or other departures from reasonable standards of professionalism will be cause for rejection by the Engineer.

The words and symbols shall be as specified in Table 1 in Article 780.12.

780.05 Thermoplastic. Prior to applying the thermoplastic pavement markings, the existing pavement markings shall be removed according to Section 783. The area removed shall be no wider than the width of the existing pavement markings. The new thermoplastic pavement markings shall be applied over the location where the pavement markings were removed.

The Contractor shall notify the Engineer 72 hours prior to the placement of the thermoplastic markings. At the time of this notification, the Contractor shall indicate the manufacturer and lot numbers of thermoplastic and glass beads he/she intends to use.

The compound shall be installed in a molten state at a minimum temperature of 400 °F (205 °C) and maximum temperature of 475 °F (245 °C). Scorching or discoloration of material will be cause for rejection by the Engineer. The machinery

shall be constructed so all mixing and conveying parts, up to and including the shaping-die, maintain the material in a molten state.

Thermoplastic shall be applied only when the pavement temperature is 55 °F (13 °C) or greater and no later than November 1 or earlier than April 15. If the thermoplastic markings cannot be placed according to these specifications and the road is to be opened to traffic between November 1 and April 15 and no adequate pavement markings are in place, the Contractor shall, at the direction of the Engineer, place temporary pavement markings according to Section 703. The Contractor shall remove the temporary pavement markings and place the thermoplastic pavement markings on or after April 15 or as agreed upon by the Engineer.

A binder sealer shall be applied on all hot-mix asphalt (HMA) pavements over 60 days old and on all portland cement concrete pavement surfaces where the new thermoplastic material is to be installed. The binder sealer material shall be applied as recommended by the manufacturer of the thermoplastic and in sufficient quantities to entirely cover the surface on which the thermoplastic is to be laid.

The thermoplastic material shall be applied at a thickness of not less than 100 mils (2.50 mm) but no greater than 110 mils (2.75 mm). Finished lines shall be within 1/4 in. (6 mm) of the width specified in the plans.

Thermoplastic markings shall be placed with drop on glass beads according to Article 1095.01, uniformly applied to assure adequate nighttime reflectivity. It shall be the Contractor's responsibility to use a compatible combination of thermoplastic material and beads to preclude the surface beads from sinking deeply into the thermoplastic.

The thickness of the markings will be measured above the pavement surface at random points as selected by the Engineer, to determine conformance.

- (a) If the measurements show less than 100 mils (2.50 mm), the Engineer will "chip" the edges of the markings at random points and measure the thickness of the chips to determine if the overall thickness of the markings is at least 100 mils (2.50 mm). When either the overall thickness or the thickness above the pavement surface is substantially in conformance with the thickness requirements, payment will be made at 100 percent of the contract unit prices involved.
- (b) If the thickness at a given location is less than 100 mils (2.50 mm), additional measurements will be taken on each side of the location by the Engineer to determine the extent of the deficient portion of the marking. If the average thickness of the deficient portion is less than 100 mils (2.50 mm) but more than 60 mils (1.50 mm), an adjusted unit price of 50 percent of the contract unit price involved will be used in computing payment for the area which is deficient.
- (c) If the measurements show the average thickness to be less than 60 mils (1.50 mm), the Contractor shall remove the surface of the deficient portions of the markings sufficiently to reduce the average thickness to approximately 50 mils (1.25 mm) or less. The Contractor shall then apply additional

thermoplastic material and beads to bring the thickness of the markings to at least 100 mils (2.50 mm) and the reflectivity to the minimum required values.

780.06 Paint. Prior to application of the paint pavement marking, the Contractor shall make certain the pavement surface is dry and free of dirt or grease and, if necessary, clean the surface to the satisfaction of the Engineer.

Paint shall not be applied at air temperatures below 50 °F (10 °C), unless approved by the Engineer.

The paint shall be applied at a minimum thickness of 16 mils (406 µm) and beads shall be applied to all painted surfaces at the minimum rate of 6.0 lb/gal (720 g/L) of paint used.

780.07 Preformed Plastic. The markings shall be capable of being applied on either new HMA surfaces by being inlaid into the surface, or on new and existing portland cement concrete and HMA surfaces, by means of a pressure-sensitive, precoated adhesive, or liquid contact cement which shall be applied at the time of installation.

The pavement shall be cleaned as recommended by the manufacturer.

Cleaning operations shall not begin until a minimum of 30 days after the placement of new portland cement concrete pavement.

The cleaning operation shall remove all visible evidence of curing compound on the peaks and valleys of textured concrete surfaces, remove all loose and flaking material, and round any sharp edges and irregularities.

When recommended by the manufacturer, a primer sealer shall be applied on all pavement surfaces where new preformed plastic pavement marking material is to be applied. The primer sealer shall be recommended by the manufacturer of the preformed plastic pavement material and shall be compatible with the material being used. The primer sealer shall be applied in sufficient quantities to entirely cover the pavement surface where the plastic material is to be placed. The Contractor shall not install the preformed plastic pavement markings until the primer sealer dries according to the manufacturer's recommendations.

The markings placed on the pavement shall be rolled and compacted onto the pavement with a roller or tamper cart approved by the manufacturer. This roller shall be loaded with or weigh at least 200 lb (90 kg). The Contractor shall tamp and roll the material sufficiently to prevent easy removal or peeling. Care shall be taken to cut the material in and around pavement joints or cracks and roll the material into the cracks of joints.

- (a) Type B - Inlaid Application. On freshly placed HMA, the inlaid markings shall be applied before final compaction and when the pavement temperature has cooled to approximately 150 °F (65 °C) and when, in the opinion of the Engineer, the pavement is acceptable for vehicular traffic.

The markings shall be applied at a minimum thickness of 60 mils (1.5 mm).

The markings shall be placed on the pavement by means of a mechanical applicator or by a hand method and embedded into the pavement surface with a static compaction roller with minimum water on the roller.

The initial rolling of the markings shall be in the same direction as the application to minimize buckling in front of the roller. The roller shall not be allowed to turn on the markings.

The markings shall be embedded to a depth of approximately 0.04 in. (1.0 mm).

- (b) Type B or C - Standard Application. The material shall be applied only when the air temperature is 60 °F (15 °C) or above and rising and the pavement temperature is 70 °F (21 °C) or greater. However, standard application of preformed plastic pavement markings will not be allowed after October 15.

When the preformed plastic markings cannot be placed according to these specifications and the road is to be opened to traffic after October 15 with no adequate pavement markings in place, the Contractor shall place preformed tape for lane lines. All other pavement markings shall be placed according to Article 703.05. The Contractor shall then place the preformed pavement markings on or as soon after April 15 as the requirements of these specifications can be met

780.08 Preformed Thermoplastic. The pavement markings shall be capable of being applied on either HMA or portland cement concrete surfaces by using a propane blowtorch.

A primer sealer recommended by the manufacturer of the preformed pavement marking material shall be applied on portland cement concrete surfaces prior to application of the preformed thermoplastic pavement marking material. The primer sealer material shall be applied in sufficient quantities to entirely cover the pavement surface where the pavement marking material is to be placed.

The pavement temperature and the ambient air temperature shall be at or above 32 °F (0 °C) at the time of installation of the pavement markings.

780.09 Epoxy. The pavement shall be cleaned by a method approved by the Engineer to remove all dirt, grease, glaze, or any other material that would reduce the adhesion of the markings with minimum or no damage to the pavement surface. New portland cement concrete pavements shall be blast-cleaned to remove all latents.

Markings shall be applied to the cleaned surface on the same calendar day. If this cannot be accomplished, the surface area shall be recleaned prior to applying the markings. No markings shall be placed until the Engineer approves the cleaning.

Widths, lengths, and shapes of the cleaned surface shall be of sufficient size to include the full area of the specified pavement marking to be placed or removed.

The cleaning operation shall be a continuous moving process with minimum interruption to any traffic.

The material shall be applied to the cleaned road surface at 20 mils \pm 1 mil (0.51 mm \pm 0.03 mm) in thickness, before the glass beads are applied. Glass beads shall be uniformly applied by means of a double drop pressurized bead applicator system. The system shall apply both the first drop glass beads and the second drop glass beads at a rate of 10 lb/gal (1.2 kg/L). Epoxy pavement marking shall be applied only when the air and surface temperatures are a minimum of 35 °F (2 °C) and rising. Where epoxy markings cannot be placed according to these specifications and the road is open to traffic with no adequate pavement markings in place, the Contractor shall place temporary pavement markings according to Article 703.05.

Lane lines shall be applied within four calendar days after removal of any existing lane lines.

The Contractor shall provide the Engineer an accurate temperature measuring device(s) which shall be capable of measuring the pavement temperature prior to the application of the material, the material temperature at the gun tip, and the material temperature prior to mixing.

The Contractor may use preformed plastic pavement marking or thermoplastic pavement marking, meeting the applicable requirements of Sections 1095 and 780, for diagonal lines, stop bars, and letters and symbols in lieu of epoxy at no additional cost to the Department.

780.10 Polyurea. There are two types of reflective media for polyurea pavement marking. Polyurea Pavement Marking Type I uses glass beads as a reflective media. Polyurea Pavement Marking, Type II uses a combination of composite reflective elements and glass beads as a reflective media.

The pavement shall be cleaned by a method approved by the Engineer to remove all dirt, grease, glaze or any other material that would reduce the adhesion of the markings with minimum or no damage to the pavement surface. New portland cement concrete pavements shall be air-blast-cleaned to remove all latents.

Markings shall be applied to the cleaned surfaces on the same calendar day. If this cannot be accomplished, the surface shall be re-cleaned prior to applying the markings. No markings shall be applied until the Engineer approves the cleaning.

Widths, lengths, and shapes of the cleaned surface shall be sufficient size to include the full area of the specified pavement marking to be placed.

The cleaning operation shall be a continuous moving operation process with minimum interruption to traffic.

The Contractor shall notify the Engineer 72 hours prior to the placement of the markings in order that he/she can be present during the operation. At the time of notification, the Contractor shall provide the Engineer the manufacturer and lot numbers of polyurea and reflective media that will be used.

The pavement markings shall be applied to the cleaned road surface, during conditions of dry weather and subsequently dry pavement surfaces at a minimum uniform wet thickness of 15 mils (0.4 mm) according to the manufacturer's installation

instructions. On new HMA surfaces the pavement markings shall be applied at a minimum uniform wet thickness of 20 mils (0.5 mm). The application of and combination of reflective media (glass beads and/or reflective elements) shall be applied at a rate specified by the manufacturer. At the time of installation the pavement surface temperature and the ambient temperature shall be above 40 °F (4 °C) and rising. The pavement markings shall not be applied if the pavement shows any visible signs of moisture or it is anticipated that damage causing moisture, such as rain showers, may occur during the installation and set periods. The Engineer will determine the atmospheric conditions and pavement surface conditions that produce satisfactory results.

Using the application equipment, the pavement markings shall be applied in the following manner as a simultaneous operation.

- (a) The surface shall be air-blasted to remove any dirt and residue.
- (b) The resin shall be mixed and heated according to the manufacturer's recommendations and sprayed onto the pavement surface.

The edge of the centerline or lane line shall be offset a minimum distance of 2 in. (50 mm) from a longitudinal crack or joint. Edge lines shall be approximately 2 in. (50 mm.) from the edge of pavement. The finished center and lane lines shall be straight, with the lateral deviation of any 10 ft (3 m) line not to exceed 1 in. (25 mm).

780.11 Inspection. The epoxy, thermoplastic, preformed thermoplastic, preformed plastic Type B or C, and polyurea pavement markings will be inspected following installation, but no later than October 15 for preformed plastic markings, November 1 for thermoplastic and preformed thermoplastic markings, and December 15 for epoxy and polyurea markings. In addition, they will be inspected following a winter performance period that extends 180 days from November 1.

Within 15 calendar days after the end of the winter performance period, a final performance inspection will be made. Final acceptance requirements are as follows.

- (a) Lane lines: 90 percent intact by area of each individual dashed line segment.
- (b) Crosswalks, stop lines, arrows, and words: 90 percent intact by area of each individual line, symbol, or letter.
- (c) Center lines, edge lines, gore markings, and channelizing lines: 90 percent intact by area measured over any 10 ft (3 m) length of any individual line regardless of width.
- (d) Entire project: measured in its entirety according to (a), (b), and (c) above, the entire project shall be 95 percent intact.

Upon completion of the final performance inspection, or after satisfactory completion of any necessary correction, the Engineer will notify the Contractor, in writing, of the date of such final performance inspection and release him/her from further performance responsibility.

If this inspection discloses any work, in whole or in part, which does not meet the inspection requirements, the Contractor shall, within 30 calendar days, completely repair or replace such work to the satisfaction of the Engineer.

This performance inspection and performance acceptance of the epoxy, thermoplastic, preformed thermoplastic, preformed plastic Type B and C pavement, and polyurea markings shall not delay acceptance of the entire project and final payment due if the Contractor requires and receives from the subcontractor a third party "performance" bond naming the Department as obligee in the full amount of all pavement marking quantities listed in the contract, multiplied by the contract unit price. The bond shall be executed prior to acceptance and final payment of the non-pavement marking items and shall be in full force and effect until final performance inspection and performance acceptance of the epoxy, thermoplastic, preformed thermoplastic, preformed plastic, and polyurea pavement markings. Execution of the third party bond shall be the option of the Contractor.

780.12 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirements for the use of contract quantities shall be according to Article 202.07(a).
- (b) Measured Quantities. Lines will be measured for payment in place in feet (meters). Double yellow lines will be measured as two separate lines.

Words and symbols shall conform to the sizes and dimensions specified in the Illinois Manual on Uniform Traffic Control Devices and Standard 780001 and will be measured based on the total areas indicated in Table 1 or as specified in the plans.

Removal of existing pavement markings will be measured for payment according to Article 783.05.

780.13 Basis of Payment. This work will be paid for at the contract unit prices per foot (meter) of applied line width, as specified, for THERMOPLASTIC PAVEMENT MARKING - LINE; PAINT PAVEMENT MARKING - LINE; EPOXY PAVEMENT MARKING - LINE; PREFORMED PLASTIC PAVEMENT MARKING - LINE - TYPE B, C, or B - INLAID; PREFORMED THERMOPLASTIC PAVEMENT MARKING - LINE, POLYUREA PAVEMENT MARKING TYPE I - LINE, POLYUREA PAVEMENT MARKING TYPE II - LINE; and/or per square foot (square meter) for THERMOPLASTIC PAVEMENT MARKING - LETTERS AND SYMBOLS; PAINT PAVEMENT MARKING - LETTERS AND SYMBOLS; EPOXY PAVEMENT MARKING - LETTERS AND SYMBOLS; PREFORMED PLASTIC PAVEMENT MARKING - TYPE B, C, or B - INLAID - LETTERS AND SYMBOLS; PREFORMED THERMOPLASTIC PAVEMENT MARKING - LETTERS AND SYMBOLS.

When the Contractor has the option of applying Permanent Pavement Marking it shall be Thermoplastic, Preformed Plastic (Type B, C, or B - Inlaid), Epoxy, or Preformed Thermoplastic Pavement Markings. It will be paid for at the contract unit price per foot (meter) of applied line for PERMANENT PAVEMENT MARKING - LINE 4 (100), 5 (125), 6 (150), 8 (200), 12 (300), 16 (400), or 24 in. (600 mm) and per

square foot (square meter) for PERMANENT PAVEMENT MARKING - LETTERS AND SYMBOLS.

Temporary pavement markings placed in lieu of permanent will be paid for according to Article 703.07.

Removal of existing pavement markings will be paid for according to Article 783.06.

*TABLE 1

LETTERS
sq ft (sq m)

Size	A	B	C	D	E	F	G	H	I
6 ft (1.8 m)	3.1 (0.28)	4.0 (0.37)	2.7 (0.25)	3.4 (0.31)	3.3 (0.31)	2.6 (0.24)	3.3 (0.31)	3.4 (0.31)	1.5 (0.14)
8 ft (2.4 m)	5.5 (0.51)	7.1 (0.66)	4.8 (0.45)	6.1 (0.57)	5.9 (0.55)	4.7 (0.44)	5.8 (0.54)	6.0 (0.56)	2.6 (0.24)

Size	J	K	L	M	N	O	P	Q	R
6 ft (1.8 m)	2.1 (0.2)	3.1 (0.28)	2.2 (0.20)	4.2 (0.39)	4.0 (0.37)	3.4 (0.31)	3.0 (0.28)	3.6 (0.33)	3.6 (0.33)
8 ft (2.4 m)	3.7 (0.34)	5.7 (0.53)	3.8 (0.45)	7.4 (0.69)	7.1 (0.65)	6.0 (0.56)	5.3 (0.49)	6.3 (0.59)	6.3 (0.59)

Size	S	T	U	V	W	X	Y	Z
6 ft (1.8 m)	3.2 (0.30)	2.2 (0.20)	3.2 (0.30)	2.7 (0.25)	4.2 (0.39)	2.7 (0.25)	2.2 (0.20)	2.9 (0.26)
8 ft (2.4 m)	5.7 (0.53)	3.8 (0.35)	5.6 (0.52)	4.8 (0.45)	7.3 (0.68)	4.8 (0.45)	3.9 (0.36)	5.1 (0.47)

NUMBERS
sq ft (sq m)

Size	1	2	3	4	5
6 ft (1.8 m)	1.5 (0.14)	3.3 (0.31)	3.3 (0.31)	2.9 (0.26)	3.5 (0.33)
8 ft (2.4 m)	2.6 (0.24)	5.8 (0.54)	5.8 (0.54)	5.1 (0.47)	6.1 (0.57)

Size	6	7	8	9	0
6 ft (1.8 m)	3.5 (0.33)	2.2 (0.20)	3.8 (0.35)	3.5 (0.33)	3.4 (0.31)
8 ft (2.4 m)	6.2 (0.58)	3.8 (0.35)	6.7 (0.62)	6.2 (0.58)	6.0 (0.56)

SYMBOLS

Symbol	Large Size sq ft (sq m)	Small Size sq ft (sq m)
Through Arrow	11.5 (1.07)	6.5 (0.60)
Left or Right Arrow	15.6 (1.47)	8.8 (0.82)
2 Arrow Combination Left (or Right) and Through	26.0 (2.42)	14.7 (1.37)
3 Arrow Combination Left, Right, and Through	38.4 (3.56)	20.9 (1.94)
Lane Drop Arrow	41.5 (3.86)	--
Wrong Way Arrow	24.3 (2.26)	--
Railroad "R" 6 ft (1.8 m)	3.6 (0.33)	--
Railroad "X" 20 ft (6.1 m)	54.0 (5.02)	--
Handicapped Symbol	4.6 (0.43)	--

*Table applies to all types of pavement marking materials.

SECTION 781. RAISED REFLECTIVE PAVEMENT MARKERS

781.01 Description. This work shall consist of placing permanent and/or temporary raised reflective pavement markers or replacing the reflective element in a raised reflective pavement marker.

781.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Raised Reflective Pavement Markers	1096.01
(b) Temporary Raised Reflective Pavement Markers	1096.02

CONSTRUCTION REQUIREMENTS

781.03 General. The reflector may be attached to the casting prior to or after the placement of the markers. The depression in the web shall be clean and dry. The reflector shall be laminated to an elastomeric pad and adhesively attached to the casting. The protective paper or plastic film covering the adhesive pad shall be removed immediately prior to placing the reflector on the casting. Once the film covering is removed, extreme care shall be taken to avoid contamination of the exposed pad surface. An adhesive meeting the marker manufacturer's specifications shall be used. The adhesive shall be placed either on the reflector or on the web in sufficient quantity so as to ensure complete coverage of the contact area with no voids present and with a slight excess after the reflector is pressed in place.

- (a) Permanent. It shall be the Contractor's responsibility to determine the location of any traffic control devices installed in the pavement before beginning work, and shall conduct work to avoid damage to these devices. Any damage to these devices caused by the Contractor's operation shall be repaired.

The pavement shall be cut to match the bottom contour of the marker using a concrete saw fitted with 18 and 20 in. (450 and 500 mm) diameter blades. Diamond blades shall be used on portland cement concrete pavement. The cut shall be clean and completely dry prior to pouring the epoxy. After the cut is cleaned, the configuration shall be checked using a pavement marker. The marker shall fit easily within the cut with the leveling tabs resting on the pavement. If any force is required to place or remove the marker or if the leveling tabs do not rest on the pavement surface, the cut shall be enlarged as necessary. Installations on crowned pavements, super elevations, or ramps shall be cut deeper than those on level pavements if necessary to get proper marker fit. A rapid setting (hard in one hour) epoxy meeting the requirements of AASHTO M 237 shall be poured into the cut to within 3/8 in. (9 mm) of the pavement surface. The installed height for the reflective pavement markers shall be approximately 0.3 in. (7.5 mm) above the road surface.

The marker shall then be placed into the epoxy-filled cut. The leveling tabs shall rest on the pavement surface and the marker tips shall be slightly below the pavement surface when properly installed. There shall be no epoxy on the reflective lens. The epoxy, when properly mixed, shall be hard cured in 30-45 minutes. If after one hour, a screwdriver or other appointed instrument can be pushed into the epoxy, the marker and the uncured epoxy shall be removed, and the marker shall be cleaned and the unit reinstalled.

The pavement surface temperature and the ambient air temperature shall be at or above 50 °F (10 °C) at the time of installation of the marker for the epoxy adhesive to properly cure.

Unless directed by the Engineer, raised reflective pavement markers shall not be laid directly over a longitudinal crack or joint. The edge of a raised reflective pavement marker shall be offset, toward traffic, a minimum distance of 2 in. (50 mm) from the edge of pavement, a longitudinal crack or joint, or a solid lane line. Raised reflective pavement markers shall be centered in the gap between dashed line segments and the finished line of the markers shall be straight. The lateral deviation on any 10 ft (3 m) line shall not exceed 1 in. (25 mm). Raised reflective pavement markers through tangents of reverse curves which are less than 500 ft (150 m) in length shall be installed at the lesser of the two curve spacings.

The reflectors may be attached to the castings either prior to or after the placement of the markers. The depression in the web shall be clean and dry. The reflector shall be placed on the casting with sufficient pressure to firmly seat it in place, minimum load of 100 lb (45 kg). Adhesive material shall not be permitted on the reflective surface of the prismatic reflector.

- (b) Temporary. The pavement surface which the marker shall be bonded to, shall be free of dirt, curing compound, grease, oil, moisture, or any other material which would adversely affect the bond of the adhesive.

The markers shall be placed firmly on the pavement and pressed into place by slowly passing over them with a truck wheel. The pass shall not displace

the markers. In lieu of an adhesive pad, an adhesive meeting the marker manufacturer's specifications may be used. The adhesive shall be placed either on the reflector or on the web in sufficient quantity so as to ensure complete coverage of the contact area with no voids present and with a slight excess after the reflector is pressed in place.

All markers shall be monodirectional. Markers placed to the left of traffic shall be amber and markers placed to the right of traffic shall be crystal.

- (c) Replacement. All remaining portions of the existing reflector, and all traces of adhesive, rust, dirt, etc., shall be removed from the marker reflector area by sandblasting or other methods approved by the Engineer.

The Contractor shall be responsible for verifying the model numbers of castings as shown on the plans and shall be responsible for installing the proper replacement reflector in each casting.

The Contractor shall make certain the casting surface is dry and free of dirt and rust prior to placing the reflector on the casting.

The reflector shall be placed on the casting with sufficient pressure to firmly seat it in place, minimum load of 100 lb (45 kg). Adhesive material shall not be permitted on the reflective surface of the prismatic reflector. The pavement surface temperature and the ambient air temperature shall be at or above 50 °F (10 °C) at the time of application of the prismatic reflector.

781.04 Inspection of Raised Reflective Pavement Markers. The permanent raised reflective pavement marker and/or replacement reflector will be inspected following installation, but no later than November 30. In addition, they will be inspected following a winter performance period that will extend 180 days from November 30.

Within 15 calendar days after the end of the winter performance period, a final performance inspection will be made. If this inspection discloses any work which is not visibly intact and serviceable, the Contractor shall, within 30 calendar days, completely repair or replace such work to the satisfaction of the Engineer.

Measured in its entirety, the work shall be 97 percent intact.

Upon completion of the final performance inspection or after satisfactory completion of any necessary corrections, the Engineer shall notify the Contractor in writing of the date of such final performance inspection and release him/her from further performance responsibility.

This delay in performance inspection and performance acceptance of the raised reflective pavement markers shall not delay acceptance of the entire project and final payment due if the Contractor requires and receives from the subcontractor a third party "performance" bond naming the Department as obligee in the full amount of all raised reflective pavement marker quantities listed in the contract, multiplied by the contract unit price. The bond shall be executed prior to acceptance and final pavement of the nonraised reflective pavement marker items and shall be in full force and effect until final performance inspection and performance acceptance of the

raised reflective pavement markers. Execution of the third party bond shall be the option of the prime Contractor.

781.05 Basis of Payment. This work will be paid for at the contract unit price per each for RAISED REFLECTIVE PAVEMENT MARKER, RAISED REFLECTIVE PAVEMENT MARKER (BRIDGE), TEMPORARY RAISED REFLECTIVE PAVEMENT MARKER, or REPLACEMENT REFLECTOR.

SECTION 782. PRISMATIC REFLECTORS

782.01 Description. This work shall consist of furnishing and installing prismatic reflectors on concrete barriers, bridge parapet walls, and mountable or barrier curbs.

782.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Prismatic Barrier Reflectors	1097
(b) Prismatic Curb Reflectors	1097

CONSTRUCTION REQUIREMENTS

782.03 General. The surface of the barrier, bridge parapet wall or curb to which the reflector shall be applied shall be free of dirt, curing compound, moisture, paint, or any other material which would adversely affect the bond of the adhesive. Cleaning of the surface shall be to the satisfaction of the Engineer.

An adhesive meeting the reflector manufacturer's specifications shall be placed either on the surface or the bottom of the reflector in sufficient quantity to ensure complete coverage of the contact area with no voids present and with a slight excess after the reflector is pressed firmly in place.

The installed height of the prismatic curb reflectors shall be a maximum of 3/4 in. (19 mm) above the mounting surface. The unit shall have one reflective surface that is placed approximately perpendicular to the mounting surface.

782.04 Basis of Payment. This work will be paid for at the contract unit price per each for MONODIRECTIONAL or BIDIRECTIONAL, PRISMATIC BARRIER REFLECTOR, and PRISMATIC CURB REFLECTOR. Where bidirectional units (two reflective surfaces) are specified, the Contractor may, at no extra cost to the Department, furnish two separate monodirectional units (single reflective surface) and mount them back to back.

SECTION 783. PAVEMENT MARKING AND MARKER REMOVAL

783.01 Description. This work shall consist of removing existing pavement markings and raised reflective pavement markers.

783.02 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Portable Shot Blast Equipment	1101.13
(b) Grinders (Note 1)	
(c) Water Blaster with Vacuum Recovery	1101.12

Note 1. Grinding equipment shall be approved by the Engineer.

CONSTRUCTION REQUIREMENTS

783.03 Removal of Conflicting Markings. Existing pavement markings that conflict with revised traffic patterns shall be removed as directed by the Engineer and shall be scheduled immediately to facilitate a change in lane assignments which requires removal of conflicting markings. If darkness or inclement weather prohibits the removal operations, such operations shall be resumed the next morning or when weather permits. In the event of removal equipment failure, such equipment shall be repaired, replaced, or leased so removal operations can be resumed within 24 hours.

- (a) **Pavement Markings.** The existing pavement markings shall be removed from the pavement by a method that does not materially damage the surface or texture of the pavement or surfacing. Very small particles of tightly adhering existing markings may remain in place, if in the opinion of the Engineer, complete removal of the small particles will result in pavement surface damage. Any damage to the pavement or surfacing caused by pavement marking removal shall be repaired by methods acceptable to the Engineer.

The shape of the obliterated strip shall be disguised so the pattern of the removed marking is not retained. Where mechanical means of marking removal have been employed, flat paint of a color matching the pavement surface or an asphaltic seal coat may be used if necessary as a means of covering contrasting pavement texture. The use of flat paint to cover conflicting pavement markings will not be allowed.

- (b) **Pavement Markers.** The removal of existing markers shall consist of the reflective element and the base casting complete. On those improvements where no pavement rehabilitation is required, the pavement shall be repaired with material according to Article 406.05 to the satisfaction of the Engineer.

When permanent raised reflective pavement markers are present and conflict with the revised traffic patterns, only the reflectors shall be removed.

783.04 Cleaning. The roadway surface shall be cleaned of debris, blast sand, or any other deleterious material by the use of compressed air, water blast, or shotblast. When the shotblast method is used, the steel shot shall be collected.

Over cleaning to the extent of possible damage to the roadway surface shall be held to a minimum.

783.05 Method of Measurement. This work will be measured for payment as follows.

- (a) Contract Quantities. The requirement for use of contract quantities shall be according to Article 202.07(a).
- (b) Measured Quantities. The existing pavement marking removal will be measured in square feet (square meters). All existing lines, letters, and symbols will be measured in square feet (square meters).

783.06 Basis of Payment. This work will be paid for at the contract unit price per each for RAISED REFLECTIVE PAVEMENT MARKER REMOVAL, or at the contract unit price per square foot (square meter) for PAVEMENT MARKING REMOVAL.

DIVISION 800. ELECTRICAL**GENERAL ELECTRICAL REQUIREMENTS****SECTION 801. ELECTRICAL REQUIREMENTS**

801.01 Definition. Codes, standards, and industry specifications cited for electrical work shall be by definition the latest adopted version thereof, unless indicated otherwise.

Materials by definition shall include electrical equipment, fittings, devices, motors, appliances, fixtures, apparatus, all hardware and appurtenances, and the like, used as part of, or in connection with, electrical installation.

801.02 Standards of Installation. Materials shall be installed according to the manufacturer's recommendations, the NEC, OSHA, the NESC, and AASHTO's Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

All like materials shall be from the same manufacturer. Listed and labeled materials shall be used whenever possible. The listing shall be according to UL or an approved equivalent.

801.03 Safety and Protection. Safety and protection requirements shall be as follows.

- (a) **Safety.** Electrical systems shall not be left in an exposed or otherwise hazardous condition. All electrical boxes, cabinets, pole handholes, etc. which contain wiring, either energized or nonenergized, shall be closed or shall have covers in place and be locked when possible, during nonworking hours.
- (b) **Protection.** Electrical raceway or duct openings shall be capped or otherwise sealed from the entrance of water and dirt. Wiring shall be protected from mechanical injury.

801.04 Equipment Grounding Conductor. All electrical systems, materials, and appurtenances shall be grounded. Good ground continuity throughout the electrical system shall be assured, even though every detail of the requirements is not specified or shown. Electrical circuits shall have a continuous insulated equipment grounding conductor. When metallic conduit is used, it shall be bonded to the equipment grounding conductor, but shall not be used as the equipment grounding conductor.

Detector loop lead-in circuits, circuits under 50 volts, and runs of fiber optic cable will not require an equipment grounding conductor.

Where connections are made to painted surfaces, the paint shall be scraped to fully expose metal at the connection point. After the connection is completed, the paint system shall be repaired to the satisfaction of the Engineer.

Bonding of all boxes and other metallic enclosures throughout the wiring system to the equipment grounding conductor shall be made using a splice and pigtail connection. Mechanical connectors shall have a serrated washer at the contact surface.

All connections to structural steel or fencing shall be made with exothermic welds. Care shall be taken not to weaken load carrying members. Where connections are made to epoxy coated reinforcing steel, the epoxy coating shall be sufficiently removed to facilitate a mechanical connection. The epoxy coating shall be repaired to the satisfaction of the Engineer. Where connections are made to insulated conductors, the connection shall be wrapped with at least four layers of electrical tape extended 6 in. (150 mm) onto the conductor insulation.

801.05 Submittals. At the preconstruction meeting, the Contractor shall submit a written listing of manufacturers for all major electrical and mechanical items. The list of manufacturers shall be binding, except by written request from the Contractor and approval by the Engineer. The request shall include acceptable reasons and documentation for the change.

Major items shall include, but not limited to the following.

Type of Work	Item
All Electrical Work	Electric Service Metering Emergency Standby System Transformers Cable Unit Duct Splices Conduit Surge Suppression System
Lighting	Tower Pole Luminaire Foundation Breakaway Device Controllers Control Cabinet and Peripherals
Traffic Signals	Signal Controller Master Controller Controller Cabinet and Peripherals Mast Arm Assembly Signal Head Detector Loop Fiber Optic Cable
Pump Stations	Pump Motor Motor Control System HVAC Level Control System SCADA Fire Alarm and Gas Detection System Effluent Screening and Mixing System Overhead Crane Security System

- (a) Non-Traffic Signal Installations. Within 30 calendar days after contract execution, the Contractor shall submit, for approval, one copy each of the manufacturer's product data (for standard products and components) and detailed shop drawings (for fabricated items). Submittals for the materials for each individual pay item shall be complete in every respect. Submittals which include multiple pay items shall have all submittal material for each item or group of items covered by a particular specification, grouped together and the applicable pay item identified. Various submittals shall, when taken together, form a complete coordinated package. A partial submittal will be returned without review unless prior written permission is obtained from the Engineer.

The submittal shall be properly identified by route, section, county, and contract number.

The Contractor shall have reviewed the submittal material and affixed his/her stamp of approval, with date and signature, for each individual item. In case of subcontractor submittal, both the subcontractor and the Contractor shall review, sign, and stamp their approval on the submittal.

Illegible print, incompleteness, inaccuracy, or lack of coordination will be grounds for rejection.

The Engineer will review the submittals for conformance with the design concept of the project according to Article 105.04 and the following. The Engineer will stamp the drawings indicating their status as "Approved", "Approved as Noted", "Rejected", or "Information Only". Since the Engineer's review is for conformance with the design concept only, it shall be the Contractor's responsibility to coordinate the various items into a working system as specified. The Contractor shall not be relieved from responsibility for errors or omissions in the shop, working, or layout drawings by the Engineer's approval thereof. The Contractor shall still be in full compliance with contract and specification requirements.

All submitted items reviewed and marked "Rejected" shall be resubmitted by the Contractor in their entirety, unless otherwise indicated within the submittal comments.

Work shall not begin until the Engineer has approved the submittal. Material installed prior to approval by the Engineer, will be subject to removal and replacement at no additional cost to the Department.

- (b) Traffic Signal Installations. At the preconstruction meeting, the Contractor shall submit the following items for materials used in construction of traffic signals for approval by the Engineer.
- (1) Five complete copies of the manufacturer's descriptive literatures and technical data for the traffic signal materials. The descriptive literatures and technical data shall be adequate for determining whether the materials meet the requirements of the plans and specifications. If the

literature contains more than one item, the Contractor shall indicate which item or items will be furnished.

- (2) Five complete copies of the shop drawings for the mast arm assemblies and poles, and the combination mast arm assemblies and poles showing, in detail, the fabrication thereof and the certified mill analyses of the materials used in the fabrication, anchor rods, and reinforcing materials.
- (3) Samples of all conduit and cable, and samples of each type of cable splice that will be used in the work.

Unless otherwise approved by the Engineer, all of the above items shall be submitted to the Engineer at the same time. Each item shall be properly identified by route, section, and contract number.

The Engineer will review the literature and furnish written approval or disapproval to the Contractor within 30 calendar days after receipt of the literature. If the literature is disapproved, the Contractor shall resubmit corrected literature within 15 calendar days of receipt of disapproval. Within ten calendar days after receipt of written approval of any signal material, the Contractor shall order such signal material and shall furnish a copy of such order to the Engineer.

801.06 Certifications. When certifications are specified and are available prior to material manufacture, the certification shall be included in the submittal information. When specified and only available after manufacture, the submittal shall include a statement of intent to furnish certification. All certificates shall be complete with all appropriate test dates and data.

801.07 Documentation for Electronic Materials. The Contractor shall furnish three copies of the manufacturer's documentation, to the Engineer, for the following items:

- Signal controllers and master controllers.
- Inductive loop detectors and light detector amplifiers.
- Preemptors.
- Transceivers.
- Load switches.
- Conflict monitors/malfunction management unit.
- High mast tower lowering devices.
- Pump station controls, communications, and backup systems.
- Any other item providing a logic, timing, or communication function.

The documentation shall include:

- Operations manual (including installation, start-up, and testing procedures)
- Service manuals.
- Circuit board schematics.
- Pictorial layout of circuit board components.
- Parts list.

The Contractor shall also furnish, to the Engineer, five copies of the controller cabinet wiring diagrams.

When approved by the Engineer, electronic copies of the documentation may be submitted in PDF format in lieu of paper copies.

801.08 Authorized Project Delay. For working day contracts, the Contractor may request to delay the start of work for a period of up to 120 consecutive calendar days after the execution of the contract for the delivery of long lead time electrical materials. This delay shall be requested by the Contractor at or prior to the time of the preconstruction meeting.

When approved, the delay shall not be construed as requiring the Contractor to actually have the material on hand within such period, only that charging of working days will begin at the termination of the delay.

801.09 Marking Proposed Locations for Highway Lighting System. The Contractor shall mark or stake the proposed locations of all poles, cabinets, junction boxes, pull boxes, handholes, cable routes, pavement crossings, and other items pertinent to the work. A proposed location inspection by the Engineer shall be requested prior to any excavation, construction, or installation work after all proposed installation locations are marked. Any work installed without location approval is subject to corrective action at no additional cost to the Department.

801.10 Inspection of Work. Inspection of electrical work shall be according to Article 105.12 and the following.

- (a) Before any splice, tap, or electrical connection is covered in handholes, junction boxes, light poles, or other enclosures, the Contractor shall notify and make available such wiring for the Engineer's inspection.
- (b) The Contractor shall prepare traffic signal materials at a suitable location, meeting the approval of the Engineer, so it may be readily inspected and tested by the Engineer. Prior to testing, all components shall be identified as to the vehicle movements. The inspector will tag the material that has been inspected and it may then be delivered to the job site. No materials will be inspected unless a written request for inspection is delivered to the Engineer at least one week in advance. Materials not complying with this requirement that have been installed on the job will be done at the Contractor's own risk and may be subject to removal and replacement at no additional cost to the Department.

801.11 Maintenance and Responsibility During Construction. Lighting and traffic signals shall be maintained during construction as follows.

- (a) Lighting. Roadway lighting systems which are being replaced, including sign and navigation lighting, must remain operational throughout the project according to Coast Guard and FAA requirements and as directed by the Engineer. No lighting circuit or portion thereof shall be removed from nighttime operation without the approval of the Engineer.

- (b) Traffic Signals. The Contractor shall be responsible for maintaining the traffic signal installation in proper operating condition.

The Contractor shall perform the following maintenance procedures.

- (1) Inspection. Patrol and inspect the signal installation at least once every two weeks for proper alignment of signal heads, lamp outages, and general operation of the traffic signals.
- (2) Correction. Provide immediate corrective action to replace burned-out lamps or damaged sockets with new approved lamps or sockets. At the time of replacement, the reflector and lens shall be cleaned.
- (3) Emergency Calls. Respond to emergency calls, including but not limited to dark signals and unprogrammed flashing signals, within two hours after notification and provide immediate corrective action. The Contractor shall maintain, in stock, a sufficient amount of materials to provide temporary and permanent repairs. Any damage to the signal installation from any cause whatsoever shall be repaired or replaced by the Contractor at no additional cost to the Department.

The Contractor shall install "STOP" (R1-1-3636) signs on all approaches to the intersection as a temporary means of regulating traffic during the time of repair, when required by the Engineer.

- (4) Personnel. The Contractor shall provide the Engineer the names and telephone numbers of two persons who will be available 24 hours a day, seven days a week, to perform any necessary work on the signal installation.
- (5) The Contractor's signal responsibilities of maintenance, energy charge, and damage repair shall begin and end as follows.
 - a. New Signal Installation. The signal responsibility shall begin at the start of signal construction and shall end upon issuance of Signal Acceptance Notice by the Engineer.
 - b. Modify Existing Signals. The signal responsibility shall begin at a date mutually agreed upon between the Contractor, Engineer, and the signal maintaining agency representative, but no later than the beginning of construction by the Contractor within 400 ft (125 m) of the intersection. The signal responsibility shall end upon issuance of Signal Acceptance Notice by the Engineer. The Contractor shall not be responsible for energy charges when modifying an existing installation.
 - c. Temporary Signals Used During Construction. The signal responsibility shall begin at the start of temporary signal construction and shall end with the removal of the signal as directed by the Engineer.

If, at any time, the Contractor fails to perform any work deemed necessary by the Engineer to keep the traffic signals in proper operating condition, or if the Engineer finds it impossible to contact the designated persons to perform any work, the Department reserves the right to perform the work. The cost of such work will be deducted from the amount due the Contractor.

801.12 Damage to Electrical Systems. Should damage occur to any existing electrical systems through the Contractor's operations, the Engineer will designate the repairs as emergency or non-emergency in nature.

Emergency repairs shall be made by the Contractor, or as determined by the Engineer, the Department, or its agent. Non-emergency repairs shall be performed by the Contractor within six working days following discovery or notification. All repairs shall be performed in an expeditious manner to assure all electrical systems are operational as soon as possible. The repairs shall be performed at no additional cost to the Department.

- (a) Lighting. An outage will be considered an emergency when three or more lights on a circuit or three successive lights are not operational. Knocked down materials, which result in a danger to the motoring public, will be considered an emergency repair.

Temporary aerial multi-conductor cable, with grounded messenger cable, will be permitted if it does not interfere with traffic or other operations, and if the Engineer determines it does not require unacceptable modification to existing installations.

- (b) Traffic Signals. Dark or unprogrammed flashing traffic signals will be considered an emergency. In the event that a traffic signal system is not functioning, the Contractor shall install "STOP" (R1-1-3636) signs on the approaches to the intersection as a temporary means of regulating traffic during the time of repair.
- (c) Pump Stations. Work shall be done in a manner such that the roadway served by the pump station is adequately protected from storm water and ground water at all times. If necessary, the Contractor may be required to provide alternate means of pumping to ensure that the roadway remains open.

801.13 Testing. Before final inspection, the electrical work shall be tested. Tests may be made progressively as parts of the work are completed, or may be made when the work is complete. Tests shall be made in the presence of the Engineer. Items which fail to test satisfactorily shall be repaired or replaced. Tests shall include checks of control operation, system voltages, cable insulation, and ground resistance and continuity.

The forms for recording test readings will be available from the Engineer. The Contractor shall provide the Engineer with a written report of all test data including the following:

Date of test.

Name of person performing the test.

Number of days since last rain.

Soil condition at the time of the test.

Diagram of test set-up showing distances between test equipment and grounding electrode(s).

Make and model of test equipment.

Tabulation of measurements taken and calculations made.

(a) Lighting. The following tests shall be made.

- (1) Voltage Measurements. Voltages in the cabinet from phase to phase and phase to neutral, at no load and at full load, shall be measured and recorded. Voltage readings at the last termination of each circuit shall be measured and recorded.
- (2) Insulation Resistance. Insulation resistance to ground of each circuit at the cabinet, with all loads connected, shall be measured and recorded.

On tests of new cable runs, the readings shall exceed 50 megohms for phase and neutral conductors with a connected load over 20 A, and shall exceed 100 megohms for conductors with a connected load of 20 A or less.

On tests of cable runs which include cables which were existing in service prior to this contract, the resistance readings shall be the same or better than the readings recorded at the maintenance transfer at the beginning of the contract. Measurements shall be taken with a megohm meter approved by the Engineer.

- (3) Loads. The current of each circuit, phase main, and neutral shall be measured and recorded. The Engineer may direct reasonable circuit rearrangement. The current readings shall be within ten percent of the connected load based on material ratings.
- (4) Ground Continuity. Resistance of the system ground as taken from the farthest extension of each circuit run from the controller (i.e. check of equipment ground continuity for each circuit) shall be measured and recorded. Readings shall not exceed 2.0 ohms, regardless of the length of the circuit.
- (5) Resistance of Grounding Electrodes. Resistance to ground of all grounding electrodes shall be measured and recorded. Measurements shall be made with a ground tester during dry soil conditions as approved by the Engineer. Resistance to ground shall not exceed 10 ohms.

(b) Traffic Signals. The following tests shall be made.

- (1) Testing as required by Articles 801.13(a)(4) and (5).
- (2) Detector Loops. Before and after permanently securing the loop in the pavement, the resistance, inductance, resistance to ground, and quality factor for each loop and lead-in circuit shall be tested. The loop and lead-in circuit shall have an inductance between 20 and 2500 microhenries. The resistance to ground shall be a minimum of 50 megohms under any conditions of weather or moisture. The quality factor (Q) shall be 5 or greater.
- (c) Pump Stations. Testing shall be made as required by Articles 801.13(a)(1) through (5).
- (d) Fiber Optic Communication System. The Contractor shall provide all personnel, materials, instrumentation, and supplies necessary to perform all testing.

The testing shall be performed in an accepted manner and according to the testing equipment manufacturer's recommendations.

- (1) Pre-installation Testing. An Optical Time Domain Reflectometer (OTDR) shall be used to evaluate the quality and the length of each fiber on cable reels prior to their use on the project. The fiber loss in dB/km and the length of each strand shall be recorded in the documentation. The attenuation of each fiber shall not exceed 3.5 dB/km nominal, measured at room temperature at 850 nm, and the attenuation measured shall be compared against that recorded by the manufacturer.

A hard copy of OTDR signature traces for all fibers on each cable reel shall be printed and provided in the documentation to the Engineer.

- (2) Post-Installation Testing. Each section of the cable shall be tested for the continuity and the attenuation as a minimum. If the attenuation is found not to be within the acceptable nominal values, the Contractor shall use an OTDR to locate points of localized loss caused by bends or kinks, and try to relax these bends or kinks. If this is not successful, the Contractor shall replace the damaged section of the cable at no additional cost to the Department. Splices shall not be allowed to repair the damaged section.
 - a. Attenuation Test. After installation, the end-to-end attenuation shall be measured for each link by insertion loss testing.

The launch reference cable and the receive reference cable shall provide for the attachments to the light source and to the power meter, respectively. The fiber strand in the launch cable and in the receive cable shall be of the same size and type as the fiber under test.

The launch reference cable shall be connected to the light source and the receive reference cable to the power meter. The two reference cables shall then be connected via a patch panel. A reference power reading (P1) shall then be taken and recorded.

The system link to be tested shall then be inserted between the launch and the receive reference cables using two patch panels. A test power reading (P2) shall then be taken and recorded.

The link attenuation (A) in dB shall be recorded as the difference between the reference power (P1) and the test power (P2).

Link Attenuation, $A = P1 - P2$

Where P1 = Reference Power
P2 = Test Power

This test shall be performed in both directions along the link. The direction of the test shall be recorded in the documentation.

- b. Transmitter/Receiver Power Level Tests. The output levels at the network hardware transmitters and receivers shall be measured and recorded for system documentation.

The power meter shall be connected to the transmitter side with a system jumper. The transmit power level shall then be read and recorded. The transmitter is then reconnected to the cable link and the power meter connected to the receiver side. The receiver power level shall then be read and recorded.

- c. Continuity Test. Continuity tests shall be used to determine whether a test or system jumper does or does not pass light. A continuity test shall also be used to assure that the fibers have not been crossed over in the jumper and that the transmit fiber goes to the receive fiber.

To perform continuity test, a high-intensity flashlight shall be aimed into the connector at one end, while an observer watches for a flicker of light at the other end.

801.14 Contract Guarantee. The Contractor shall provide a written guarantee for all electrical work provided under the contract for a period of six months after the date of acceptance according to Article 801.15.

All instruction sheets required to be furnished by the manufacturer for materials and supplies and for operation of the installation shall be delivered to the Engineer prior to acceptance of the project, with the following warranties and guarantees.

- (a) The manufacturer's standard written warranty for each piece of electrical material or apparatus furnished under the contract. The warranty including the maintained minimum luminance for light emitting diode (LED) modules,

optically programmed LED modules, and LED luminaires shall cover a minimum of 60 months from the date of delivery.

- (b) The Contractor's written guarantee that, for a period of six months after the date of final acceptance of the work, all necessary repairs to or replacement of said warranted material or apparatus for reasons not proven to have been caused by negligence on the part of the user or acts of a third party shall be made by the Contractor at no additional cost to the Department.
- (c) The Contractor's written guarantee for satisfactory operation of all electrical systems furnished and constructed under the contract for a period of six months after final acceptance of the work.

The warranty for an uninterruptable power supply (UPS) shall cover a minimum of two years from date the equipment is placed in operation; however, the batteries of the UPS shall be warranted for full replacement for a minimum of five years.

801.15 Acceptance. Acceptance of electrical work will be given at the time when the Department assumes the responsibility to protect and maintain the work according to Article 107.30 or at the time of final inspection.

When the electrical work is complete, tested, and fully operational, the Contractor shall schedule an inspection for acceptance with the Engineer no less than seven working days prior to the desired inspection date. The Contractor shall furnish the necessary labor and equipment to make the inspection.

A written record of the test readings taken by the Contractor according to Article 801.13 shall be furnished to the Engineer seven working days before the date the inspection is scheduled. Inspection will not be made until after the delivery of acceptable record drawings, specified certifications, and the required guarantees.

Traffic Signals. The following additional requirements shall also apply for the acceptance of traffic signals.

- (a) **Acceptance of Traffic Signal Installations.** A signal, whether a new installation or an existing modified, will be accepted with the issuance of a written Signal Acceptance Notice by the Engineer.

For interconnected signals, the Signal System Acceptance Notice covering interconnection and system operation will be issued only after the compliance with the requirements on all signals, interconnection, and system operation. The Signal Acceptance Notice may be issued for individual signals under system control that meet all the non-system requirements.

- (b) **Turn-on or Actuated Operation Inspection of Traffic Signals.** The Contractor shall request a Turn-on Inspection of a new signal installation and an Actuated Operation Inspection of an existing modified signal after the signal system has been completely installed and fully operational and when the roadway is open to traffic. For the interconnected signals (hardwire, fiber optic, or radio interconnect), all required system hardware and software including but not limited to internal and external modems, telephone drop,

master controller, interconnect cable, and Closed Loop software, shall be completely installed and fully operational prior to the system inspection request.

The inspection request shall be made to the Engineer a minimum of three working days prior to the time of the requested inspection. During the inspection, all the traffic control items will be tested for proper operation according to the contract and to the satisfaction of the Engineer. The Contractor shall be provided with a punch list indicating the items that failed the inspection and require corrective measures. Upon the Turn-on Inspection, the Engineer may allow the Contractor to activate the signal in continuous operation, but this shall not relieve the Contractor from correcting the failed items. The Contractor shall notify the Engineer when all the failed items on the punch list have been corrected and shall request an inspection. A Turn-on or Actuated Operation Inspection shall not be considered successful until each failed item on the punch list has been corrected by the Contractor to operate according to the contract and to the satisfaction of the Engineer. Only after a successful Turn-on or Actuated Operation Inspection shall the signals be considered ready for the final inspection and a 30-day on-site acceptance period shall start.

- (c) **Monitoring of Traffic Signal Installations (Thirty-day On-site Acceptance).** After a successful Turn-on or Actuated Operation Inspection, the signals shall enter a 30 calendar day minimum on-site monitoring phase. During this phase, the Contractor shall continuously monitor the operation of the traffic signal items including but not limited to controllers, master controller, inductive loop detectors, detector loop, transceivers, modems, conflict monitors, and controller cabinets with peripheral materials. If a Closed Loop system is being installed or being modified, the Contractor shall utilize the system software capabilities to monitor the traffic control items. Failure of any component during the monitoring period, with the exception of expendable items such as light bulbs and fuses, shall be reported to the Engineer and corrective measures shall be taken by the Contractor to the satisfaction of the Engineer. A failed item shall necessitate restarting the 30-day monitoring period for its full 30-day duration beginning at the time when the failed item was corrected by the Contractor to the satisfaction of the Engineer.

At the end of a successful 30-day monitoring period, the Contractor shall provide the Engineer with a monitoring log for the items covering the 30-day period. The Contractor shall utilize the system software capabilities to store and generate monitoring logs, if a Closed Loop system is being installed or modified. Upon review of the logs and further performance testing to the satisfaction of the Engineer, he/she will issue a Signal Acceptance Notice/Signal System Acceptance Notice or notify the Contractor in writing of the deficiencies.

801.16 Record Drawings. Alterations and additions to the electrical installation made during the execution of the work shall be neatly and plainly marked in red by the Contractor on the full-size set of record drawings kept at the Engineer's field office for the project. These drawings shall be updated on a daily basis and shall be available for inspection by the Engineer during the course of the work. The record

drawings shall include all plans, details, notes, schedules, single line diagrams, etc., applicable to the electrical work and other information useful to locate and maintain the electrical system. As part of the record drawings, the Contractor shall inventory all materials, new or existing, on the project and record information on inventory sheets provided by the Engineer. Upon request, a full-size set of reproducible drawings of the lighting work will be made available to the Contractor for the purpose of compliance with these requirements.

When the work is complete, and seven days before the request for a final inspection, the full-size set of contract drawings, stamped "RECORD DRAWINGS", shall be submitted to the Engineer for review and approval and shall be stamped with the date and the signature of the Contractor's supervising Engineer or electrician.

The Contractor shall provide two sets of electronically produced drawings in a moisture proof pouch to be kept on the inside door of the controller cabinet or other location approved by the Engineer. These drawings shall show the final as-built circuit orientation(s) of the project in the form of a single line diagram with all luminaires numbered and clearly identified for each circuit.

SECTION 802. RESERVED

SECTION 803. LOCATING UNDERGROUND CABLE

803.01 Description. This work shall consist of determining the exact locations of all underground electric cable and electric conductors in conduit owned and maintained by the Department, which are in possible conflict with construction operations, to protect them from damage.

CONSTRUCTION REQUIREMENTS

803.02 General. Any prints from microfilm or any information shown on the plans for existing underground electrical facilities owned and operated by the Department are intended to show electrical circuitry only, and are not intended to show exact locations of cable or conduits. The Contractor shall be responsible for determining the exact location of any such existing underground electric cable or electric conductors in conduit that are within 5 ft (1.5 m) of the limits of any excavation or penetration relative to the construction work that could interfere with the underground facilities.

Plans of existing Department owned electrical facilities may be available in the District Office in which the construction is located. Prints of applicable plans will be provided to the Contractor upon request, if available.

The Contractor shall take whatever precautions to protect the electric cable or electric conductors in conduit from damage during location and construction operations. In the event that the wiring is damaged, the Contractor shall replace the entire length of cable or conductors in conduit, in a manner satisfactory to the Engineer. Splicing below grade will not be permitted.

In the event the repairs are not made by the Contractor, the Contractor shall reimburse the Department for such repairs within 60 days of receiving written notification of said damage. Otherwise, the cost of such repairs will be deducted from monies due or which will become due the Contractor under the terms of the contract.

If, in the opinion of the Engineer, it is determined prior to any construction that existing electrical wiring at a particular location is such that damage to said wiring is impossible to avoid, the Contractor shall relocate that segment of the existing wiring to avoid his/her operations as directed by the Engineer.

803.03 Method of Measurement. This work will be measured for payment in feet (meters) in place for each single buried insulated cable containing multiple conductors, or for each single buried conduit containing multiple cables located within an area extending 5 ft (1.5 m) outside the limits of excavation or penetration in each direction. This work will be measured for payment at a specific work location only one time.

803.04 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for LOCATING UNDERGROUND CABLE, which price shall include locating each cable, or conduit and protecting it from damage during location and construction operations.

If the Contractor is requested to relocate a segment of cable or conduit at a specific work location to avoid construction operations, this work will be paid for according to Article 109.04. Only that work requested in writing by the Engineer will be paid for.

SECTION 804. ELECTRICAL SERVICE INSTALLATION - LIGHTING

804.01 Description. This work shall consist of installing, modifying, or extending an electric service installation.

804.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Conductors	1066.02
(b) Cable Insulation	1066.03
(c) Wood Pole (Note 1)	1069.04
(d) Electric Service Installation - Lighting	1086.01
(e) Electrical Raceway Materials	1088.01

Note 1. The pole shall be Class 5.

CONSTRUCTION REQUIREMENTS

804.03 Utility Coordination. The Contractor shall contact and coordinate both the work required and the timing of the installation with the electric utility.

In the event of delay by the utility, no extension of time will be considered applicable for the delay unless the Contractor can produce evidence that a written

request(s) for electric service has been sent to the utility. The initial written request must be dated no later than 30 days from contract execution.

804.04 Installation. The electric service installation shall extend beyond utility owned facilities to the point of cable termination of the incoming power to the controller cabinet. It shall be installed according to the phasing, ampere rating, and voltage shown on the plans.

The Contractor shall ascertain the work being provided by the electric utility and shall provide all additional material and work required to complete the electric service work in compliance with the requirements of the utility. All material and work, even if not specifically shown, shall be provided and included as part of the work.

The electric service installation shall include an appropriate service disconnect and when required, metering. Metering shall include all metering material including potential and current transformers. The metering and service disconnect shall be installed remote to the controller cabinet where possible.

The total length of aerial and underground service between the controller and primary transformer shall not exceed 250 ft (76 m). The service pole or above ground pedestal and controller shall be located adjacent to the right-of-way line or a minimum distance of 30 ft (9 m) from edge of pavement. The exact location will be established by the Engineer.

Raceways shall be installed according to Article 810.03 and the details shown on the plans.

Conductors shall be installed according to Article 817.03.

Grounding shall be according to Section 806.

Specific requirements for aerial and underground electric service installations shall be as follows.

- (a) **Aerial Electric Service.** The aerial service shall be mounted on a wood pole, along with a weatherhead, disconnect switch, meter base (if required), and all appurtenances to complete the installation as shown on the plans.

The wood pole shall be installed according to Article 830.03(c), except the pole shall be a minimum of 25 ft (7.5 m) in length and shall be increased as necessary to maintain ground clearance.

- (b) **Underground Electric Service.**

- (1) **Ground Mounted Service.** The ground mounted service shall be installed on a service pedestal with a cabinet, disconnect switch, metering base (if required), and all appurtenances to complete the installation as shown on the plans.

- (2) **Pole Mounted Service.** The service shall extend to a 12 ft (3.7 m) wood pole on which the metering base (if required) and service disconnect

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Electrical Service Installation - Lighting

switch shall be channel mounted according to the utility guidelines and as shown on the plans.

The wood pole shall be installed according to Article 830.03(c).

Underground cable coming up the wood pole from the utility transformer and back down the pole to the controller cabinet shall be protected in conduit protected by galvanized steel "U" guard. The "U" guard shall be attached to the pole with 3/8 x 3 in. galvanized steel lag bolts.

804.05 Basis of Payment. This work will be paid for at the contract unit price per each for ELECTRIC SERVICE INSTALLATION.

Any charges by the utility company to provide electrical service to the service installation will be paid for according to Article 109.05.

SECTION 805. ELECTRICAL SERVICE INSTALLATION - TRAFFIC SIGNALS

805.01 Description. This work shall consist of furnishing and installing an electrical service installation.

Type A service installation shall include one weather-head, one ground rod, one meter pan, one circuit breaker, one weatherproof enclosure, galvanized steel conduit, nonmetallic conduit, conduit clamps, lag screws, electric cables of the type and size specified by local utility company, and other miscellaneous items. The meter will be furnished by the utility company.

Type B service installation shall be according to the Type A service installation, except no meter will be installed.

Type C service installation shall include one weatherproof enclosure, one circuit breaker, one weather-head, one ground rod, galvanized steel conduit, conduit clamps, lag screws, electric cables of the type and size specified by a local utility company, and other miscellaneous items. The Contractor shall make connections to the line side of the circuit breaker, and coil the remainder above the junction box for installation by the utility company. No separate grounding of weatherproof enclosure will be installed, unless it is required by the utility company.

805.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Weatherhead	1086.02(a)
(b) Circuit Breaker and Weatherproof Enclosure	1086.02(b)
(c) Grounding	1086.02(c)
(d) Wood Pole	1069.04

CONSTRUCTION REQUIREMENTS

805.03 Installation. The service installation shall be installed according to the details shown on the plans. Exceptions will be made to comply with the local utility

company's standard practices. When a service pole is necessary, it shall be installed according to Article 830.03(c).

805.04 Basis of Payment. This work will be paid for at the contract unit price per each for SERVICE INSTALLATION, of the type specified.

Any charges by the utility company to provide electrical service to the service installation will be paid for according to Article 109.05.

SECTION 806. GROUNDING

806.01 Description. This work shall consist of furnishing and installing a grounding electrode(s) and connecting the grounding electrode(s) by means of a grounding electrode conductor.

806.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Grounding Electrode Conductors	1087.01(a)
(b) Grounding Electrodes	1087.01(b)
(c) Access Wells	1087.01(c)

CONSTRUCTION REQUIREMENTS

806.03 Grounding Electrodes. Cast-in-place concrete foundations shall have a grounding electrode installed at the bottom of the foundation hole, or through the concrete foundation, as shown on the plans. Other grounding applications shall have a grounding electrode installed 18 in. (450 mm) below grade. The grounding electrode conductor shall be attached to the grounding electrode by a mechanical ground clamp, except in an access well where an exothermic weld connection shall be made. Access well installed grounding electrodes shall be installed 12 in. (300 mm) below grade and filled with crushed stone from 4 in. (100 mm) below the exothermic connection to a point 20 in. (500 mm) below grade.

Testing resistance to ground shall be according to Article 801.13(a)(5). If the measured resistance to ground exceeds 10 ohms, additional rods shall be added to the grounding electrode. A maximum number of three rods shall be coupled together. If coupling three rods together does not lower the resistance to 10 ohms, then additional grounding electrodes shall be installed, a minimum of 6 ft (1.8 m) from each other and the initial installation and connected by a grounding electrode conductor to form a ground field. If the resistance to ground still exceeds 10 ohms after three sets of three coupled electrodes have been installed in the ground field or where sub-surface conditions limit the depth to which the grounding electrode(s) can be installed, the Contractor shall contact the Engineer for further instructions.

806.04 Basis of Payment. Installation and testing of the first rod for the grounding electrode will not be paid for separately, but shall be included in the cost of the item for which it is installed. If additional rods are needed, their installation and testing will be paid for according to Article 109.04.

WIREWAY AND CONDUIT SYSTEMS

SECTION 810. UNDERGROUND RACEWAYS

810.01 Description. This work shall consist of furnishing and installing conduit, fittings and accessories as part of raceway either laid in trench, bored and pulled in place, or encased in concrete.

810.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Rigid Metal Conduit	1088.01(a)
(b) Rigid Nonmetallic Conduit	1088.01(b)
(c) Coilable Nonmetallic Conduit.....	1088.01(c)
(d) Portland Cement Concrete (Note 1)	1020
(e) Underground Cable Marking Tape	1066.05
(f) Fine Aggregate	1003.04
(g) Reinforcement Bars	508

Note 1. Class SI concrete shall be used for encased conduit.

810.03 Equipment. Equipment shall be according to the following.

- (a) Cable Plow. (Note 1)
- (b) Auger. (Note 2)

Note 1. The plow shall be capable of plowing a cavity and placing the conduit to the specified depth in a single operation without kinking or otherwise damaging the conduit.

Note 2. The auger shall be a remotely steerable, fluid cutting tunneling system. The tunneling system shall be electronically detectable and shall line the tunnel with a clay lining as it tunnels.

CONSTRUCTION REQUIREMENTS

810.04 Installation. All underground conduit shall have a minimum depth of 2 1/2 or 2 ft (750 or 600 mm) below the finished grade and shall be installed to avoid existing and proposed utilities within the project limits.

At the Contractor's option, conduit shall be installed by trenching, plowing, or boring and pulling; except boring and pulling will be required under pavement, stabilized shoulder, paved median, paved driveway, curb, gutter, curb and gutter, or sidewalk.

- (a) Trenching. Trenches shall not exceed 1 ft (300 mm) in width without prior approval of the Engineer. The trenches shall be constructed to permit easy installation of conduit without twisting, kinks, or sharp bends. The bottom of

the trench shall be built up with suitable compacted backfill material so the conduit will have a smooth bed.

Where separate circuit runs are to be installed parallel with each other, one common trench shall be used. At the locations where a trench crosses other existing cable systems, the trench shall be hand dug 6.5 ft (2 m) to either side of the crossing.

Backfill material shall be free of brick, rock, or any material that could damage the conduit.

Backfill material for trenches in the subgrade of the proposed improvement, and for trenches outside of the subgrade where the inner edge of the trench is within 2 ft (600 mm) of the edge of the proposed pavement, curb, gutter, curb and gutter, stabilized shoulder, or sidewalk shall be trench backfill.

Backfill shall be deposited in uniform lifts not exceeding 6 in. (150 mm) thick loose measure. The material in each lift shall be mechanically compacted by tamping with power tools approved by the Engineer in such a manner as not to disturb or damage the conduit.

Disposal of surplus material shall be according to Article 202.03.

Underground cable marking tape shall be installed a minimum of 6 in. (150 mm) and not more than 1 ft (300 mm) below finished grade for all underground conduit runs. When fiber optic cable is to be placed in the conduit, an underground cable marking tape with a metallic detection strip shall be used. Splicing of the tape shall be accomplished with metal clips to maintain electrical continuity along the entire length of the tape. Splices shall be wrapped with a waterproof adhesive tape.

- (b) Plowing. The conduit shall be round and free of kinks when fed into the plow and placed in the ground. Pulling of the conduit within the plowed cavity will not be allowed. When more than one conduit is placed into a single plowed cavity, they shall be free of twists.

Where another circuit is plowed in parallel to the first, the distance between the two shall be not less than 1 ft (300 mm) nor more than 2 ft (600 mm).

Underground cable marking tape shall be installed according to Article 810.04(a).

- (c) Boring and Pulling. Conduit shall be installed with the use of an auger. Conduit in the subgrade of the proposed improvement shall extend a minimum of 2 ft (600 mm) beyond the edge of the proposed pavement, stabilized shoulder, paved median, paved driveway, curb, gutter, curb and gutter, or sidewalk.

Areas disturbed by the augering operation shall be restored to their original condition as directed by the Engineer.

810.05 Conduit Assembly. Conduit assemblies shall be according to the following.

- (a) Rigid Metal Conduit (Steel, Intermediate Metal, Aluminum). The ends of the conduit shall be cut square and thoroughly reamed before installation. All burrs and rough edges shall be removed.

Bends shall be made with a standard pipe bender. Bends shall be made so the conduit is not injured and the internal diameter of the conduit is not effectively reduced.

Conduit joints shall be threaded. All joints before assembly and exposed threads after assembly shall be coated with low resistance, conductive, joint compound. Running threads in conduit runs will not be permitted. Conduits shall not be over-threaded. The protective coatings on all threads must be sufficient to prevent corrosion before installation is made. If threads become corroded before installation, the material shall be replaced with new material or the corroded parts thoroughly cleaned and recoated as directed by the Engineer.

Ends of conduits shall be equipped with insulating bushings. Rigid metal conduits terminating in the base of lighting controllers, pedestal bases, transformer bases, and other open enclosures shall be equipped with insulating bushings with ground lugs. The ground lugs shall be used to bond the conduits to the enclosure via a copper grounding conductor.

Conduits terminating at cast or malleable iron boxes shall be terminated in conduit hubs. Hubs shall be integral to the box or installed separately. Non-integral hubs or integral hubs which do not provide a flared, smooth entry shall not be used and in these cases two locknuts and an insulating bushing shall be used.

Threaded conduits shall terminate with two locknuts and an insulating bushing for sheet metal enclosures above grade.

Conduit connections shall be made tight to assure good grounding continuity.

Conduit below pavement, used as sleeves, shall extend a minimum of 2 ft (600 mm) beyond the shoulder, curb, and/or guardrail.

The conduit shall be cleaned by rodding and swabbing to remove all dirt and other foreign materials and capped until conductors are installed.

- (b) Rigid Nonmetallic Conduit. The conduit shall be cut square. All burrs shall be removed from the inside and outside of the conduit.

Bending of the conduit shall be made so the conduit will not be damaged and the internal diameter of the conduit will not be effectively reduced. Bends shall be made with standard pipe bending equipment for nonmetallic conduit.

The conduit section shall be heated evenly over the entire length of the bend. The use of torches or other flame-type devices will not be allowed. Sections showing evidence of scorching or discoloration will not be acceptable.

All joints shall be test mated without forcing, then cemented. The socket depth of the fitting shall be marked on the outside of the conduit without scratching or damaging the surface. The conduit shall enter the fitting for the full depth of the socket.

Before applying cement, the surfaces to be joined shall be wiped clean and free of dirt, oil, grease, or moisture. The solvent cement shall be applied according to manufacturer's recommendations.

Immediately after applying the coat of cement to the conduit and fittings, the conduit shall be inserted into the fitting socket until it bottoms at the fitting shoulder. The conduit shall be turned 1/4 turn during insertion to distribute the cement evenly. Excess cement shall be wiped away from the outside of the joint.

Newly assembled joints shall set a minimum of ten minutes before handling.

- (c) Coilable Nonmetallic Conduit. Coilable Nonmetallic Conduit shall be installed in continuous lengths, without splicing.

Conduit extended to lighting, traffic, and sign structures shall extend 12 in. (300 mm) above the base of the structure.

Bends of conduit shall be made manually so the duct will not be damaged and the internal diameter of the duct will not be effectively reduced. No more than the equivalent of four quarter bends (360 degrees total) shall be made between termination/pull points.

- (d) Concrete-Encased Conduit. Multiple conduit runs grouped together in a duct bank shall be encased in Class SI concrete and shall be supported on interlocking plastic spacers designed for the purpose, spaced along the length of the run as recommended by the manufacturer. Spacing between raceways within a common duct bank shall be a minimum of 2 in. (50 mm). The interlocking spacers shall be used at a maximum interval of 5 ft (1.5 m).

Concrete cover overall shall be a minimum of 3 in. (75 mm) all around the encased run. During concrete placement there shall be no voids, the spacers shall be undisturbed, and the conduit joints shall stay secure and unbroken. Concrete shall be deflected during placement to minimize the possible damage to or movement of the conduits.

Conduit encased in concrete shall have steel reinforcing when installed below roadway or other paved vehicle areas (including shoulder) and the reinforcement shall extend a minimum of 5 ft (1.5 m) additional from the edge of pavement. Steel reinforcement shall be a minimum of No. 4 (No. 15) bars at corners and otherwise spaced on 12 in. (300 mm) centers, tied with No. 4 (No. 15) bars on 12 in. (300 mm) centers.

All conduit joints and supports shall be inspected and approved by the Engineer before concrete is poured.

810.06 Method of Measurement. This work will be measured for payment in feet (meters) in place. Measurements will be made in straight lines along the centerline of the conduit between ends and changes in direction.

Vertical conduit will be measured for payment. The vertical distance required for breakaway devices, barrier wall, concrete pedestals, etc., and the depth of any burial will be measured. Changes in direction shall assume perfect straight line runs, ignoring actual raceway sweeps.

810.07 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for UNDERGROUND CONDUIT, of the type and size specified.

Conduit encased in concrete will be paid at the contract unit price per foot (meter) for CONDUIT ENCASED, of the type, diameter, and number of raceways wide by the number of raceways high specified. Reinforcement bars will not be paid for separately.

SECTION 811. EXPOSED RACEWAYS

811.01 Description. This work shall consist of furnishing and installing raceways, fittings, and accessories attached to supports.

811.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Rigid Metal Conduit	1088.01(a)
(b) Expansion Fittings for Raceways	1088.02
(c) Stainless Steel Junction Box	1088.04(a)
(d) Fasteners and Hardware	1088.03

CONSTRUCTION REQUIREMENTS

811.03 Installation. Installation of exposed raceways shall be as follows.

(a) Rigid Metal Conduit. Rigid metal conduit installation shall be according to Article 810.05(a). Conduits terminating in junction and pull boxes shall be terminated with hubs, integral box hubs, or integral box bosses.

Supports. Surface-mounted conduits shall be held in place by one-hole clamps and clamp backs. Conduits mounted to steel beams or columns shall be held in place by suitable beam clamps. Clamps, clamp backs, and beam clamps shall be of hot-dipped galvanized steel or stainless steel.

Raceways suspended from the structure shall be supported by trapeze or other hangers approved by the Engineer. Trapeze hangers shall be hot-dip galvanized steel channels or angle irons with conduits held in place by

heavy-duty stainless steel U-bolts, nuts, and lock washers. Trapeze hangers shall be hung using threaded hot-dipped galvanized or stainless steel rods not less than 1/2 in. (13 mm) diameter and appropriate anchors or by other means approved by the Engineer.

Raceway supports shall be installed with a support within 3 ft (900 mm) of each cabinet, box, or fitting, except the maximum distance between supports shall be as indicated below.

Conduit Supports

Conduit Diameter		Maximum Distance Between Rigid Metal Conduit Supports	
in.	(mm)	ft	(m)
1/2-3/4	(13-20)	5	(1.5)
1	(25)	6	(1.8)
1 1/4-1 1/2	(30-40)	7	(2.1)
2-2 1/2	(50-65)	8	(2.4)
3 and larger	(75)	10	(3)

- (b) PVC Coated Rigid Steel Conduit. In addition to the methods described in Article 810.05(a) the following methods shall be observed when installing PVC coated conduit.

PVC coated conduit pipe vise jaw adapters shall be used when the conduit is being clamped to avoid damaging the PVC coating.

PVC coated conduit shall be cut with a roller cutter or by other means approved by the conduit manufacturer.

After any cutting or threading operations are completed, the bare steel shall be touched up with the conduit manufacturer's touch up compound.

- (c) Expansion Joints. Expansion joints shall be installed as follows.

- (1) Liquid Tight Flexible Nonmetallic Conduit (LFNC). LFNC shall not be used in lieu of bending conduit. LFNC shall only be used to isolate structure to structure movement or to isolate vibration as shown on the plans.

LFNC shall not exceed 36 in. (900 mm) in length unless approved by the Engineer. All LFNC shall terminate in a stainless steel junction box installed according to Section 813. Fittings designed for use with liquid-tight flexible conduit shall be used at all connections.

- (2) Expansion Fittings. The fittings shall be precisely aligned with the conduit run to assure proper expansion and deflection operation and prevent binding.

For vertical conduit runs, the fitting shall be installed close to the top of the structure to prevent water running across the fitting and entering the conduit.

The fitting's deflection sleeve coupling, and pressure bushing at the barrel of the expansion body, shall be installed flush with the structure ends so that only the connecting expansion nipple crosses the opening between structures.

The fitting shall be supported by points on the conduit immediately adjacent to the fitting. The fitting shall have an external bonding jumper.

811.04 Method of Measurement. This work will be measured for payment in feet (meters) in place. Measurements will be made in straight lines along the centerline of the conduit between ends and changes in direction. Changes in direction shall assume perfect straight line runs, ignoring actual raceway sweeps.

Expansion fittings or LFNC and stainless steel junction boxes will not be measured for payment.

811.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for CONDUIT ATTACHED TO STRUCTURE, of the type and diameter specified.

SECTION 812. RACEWAYS EMBEDDED IN STRUCTURE

812.01 Description. This work shall consist of furnishing and installing rigid conduit, fittings, and accessories embedded in concrete structures.

812.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Rigid Metal Conduit	1088.01(a)
(b) Rigid Nonmetallic Conduit	1088.01(b)
(c) Expansion Fittings for Raceways	1088.02
(d) Stainless Steel Junction Box	1088.04(a)
(e) Fasteners and Hardware	1088.03

CONSTRUCTION REQUIREMENTS

812.03 Installation. Conduit embedded in a structure shall be supported on interlocking plastic spacers specifically designed for that purpose and spaced along the length of the run as recommended by the manufacturer. Spacing between raceways within a common structure shall be not less than 2 in. (50 mm). The interlocking spacers shall be used at a maximum interval of 5 ft (1.5 m). When approved by the Engineer, the conduit may be tied to the reinforcement where the reinforcement precludes the use of the supports.

Concrete cover shall not be less than 3 in. (75 mm) all around the embedded conduit run. During concrete placement, spacers and conduit joints shall stay secure

and unbroken. Concrete shall be deflected during placement to minimize the possible damage to, or movement of, the conduits.

All conduit joints and supports shall be inspected and approved by the Engineer before concrete is poured.

Raceways shall be protected from mechanical and physical damage during construction. Open raceway ends shall be capped in accordance with manufacturer's recommendations. Raceways shall be cleared of all dirt, water, excess concrete, and other foreign materials with a dry swab and pull rope carrier. Internal obstructions shall be repaired to the satisfaction of the Engineer.

The embedded conduit shall be continuous as shown on the plans, with no break or obstruction between junction boxes and through the entire raceway system. A 3/8 in. (9 mm) nylon rope shall be blown through following a pull rope carrier being pulled or blown through the conduit to demonstrate continuity between junction boxes and through the entire raceway system. The size(s) of the pull rope carrier shall be in accordance with the size(s) of the conduit as shown on the plans. The rope shall be left in the conduit, and shall be continuous between junction boxes and between all conduit terminal points. Each rope end shall be securely fitted with a washer or other approved device, of a diameter larger than the conduit diameter, to prevent the rope from coiling back inside the conduit and to insure accessibility for the installation of cables.

- (a) Rigid Metal Conduit. Conduit assemblies shall be prepared according to Article 810.05(a).
- (b) Rigid Nonmetallic Conduit. Conduit assemblies shall be prepared according to Article 810.05(b).
- (c) Expansion Joints. Expansion joints shall be installed as follows.
 - (1) Expansion Fittings. Expansion fittings shall be installed according to Article 811.03(c)(2).
 - (2) Liquid Tight Flexible Nonmetallic Conduit (LFNC). With the approval of the Engineer, LFNC with stainless steel junction boxes may be used in lieu of an expansion fitting. The LFNC shall be installed according to Article 811.03(c)(1). Stainless steel junction boxes shall be installed according to Section 813.

812.04 Method of Measurement. This work will be measured for payment in feet (meters) in place. Measurements will be made in a straight line along the centerline of the conduit between ends and changes in direction.

Vertical conduit will be measured for payment. The vertical distance required for breakaway devices, barrier wall, concrete pedestals, etc., will be measured. Changes in direction shall assume perfect straight line runs, ignoring actual raceway sweeps.

Expansion fittings or LFNC and stainless steel junction boxes will not be measured for payment.

812.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for CONDUIT EMBEDDED IN STRUCTURE, of the type and diameter specified.

SECTION 813. JUNCTION BOXES

813.01 Description. This work shall consist of furnishing and installing a junction box.

813.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Junction Box	1088.04
(b) Electrical Raceway Materials	1088.01

CONSTRUCTION REQUIREMENTS

813.03 Installation. Exposed junction boxes on structures shall be installed on 1/2 in. (13 mm) long stainless steel or brass spacers with the hinge on the side of the box and the cover lying in the vertical plane when closed. The exact orientation shall be as shown on the plans or as directed by the Engineer. Care shall be taken to assure proper orientation of mounting lugs.

The embedded junction box shall be set flush with the adjoining surface and shall be properly supported during concrete placement. Concrete cover shall not be less than 3 in. (75 mm) all around the embedded junction box.

Field cut conduit openings shall be uniform and smooth. All burrs and rough edges shall be filed smooth prior to the installation of conduit(s) into the junction box. Field cut conduit openings shall be fitted with the appropriate conduit fittings and accessories.

813.04 Basis of Payment. This work will be paid for at the contract unit price per each for JUNCTION BOX ATTACHED TO STRUCTURE; or JUNCTION BOX EMBEDDED IN STRUCTURE, of the type and size when specified.

SECTION 814. HANDHOLE

814.01 Description. This work shall consist of furnishing and installing or constructing a handhole, a heavy-duty handhole, or a double handhole.

814.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate for French Drains (Note 1)	1004.05
(b) Portland Cement Concrete (Note 2)	1020
(c) Composite Concrete Handhole (Note 3)	1088.05
(d) Handhole Frame and Cover	1088.06

Note 1. Gradation CA 5 or CA 7 shall be used.

Note 2. Class SI concrete shall be used.

Note 3. All hardware used for assembling a composite concrete handhole shall be galvanized or stainless steel.

CONSTRUCTION REQUIREMENTS

814.03 Construction. The location of the handhole shall be excavated so that the top of the handhole is set flush with the sidewalk or paved surface. When installed in earth shoulder away from the pavement edge, the top surface of the handhole shall be 1 in. (25 mm) above the finished grade. The excavation shall be deep enough to accommodate the depth of the box and french drain.

The french drain shall be constructed underneath the proposed handhole according to Article 601.06.

Handholes shall be constructed of cast-in-place portland cement concrete with a frame and cover, or composite concrete. Heavy duty handholes shall be cast-in-place only.

- (a) Cast-in-Place. The method of forming the handhole and placing the concrete shall be approved by the Engineer.

The handhole frame and cover shall be set accurately to the finished elevation so no subsequent adjustment will be necessary.

Where a handhole is contiguous to a sidewalk, preformed joint filler of 1/2 in. (13 mm) thickness shall be placed between the handhole and the sidewalk.

- (b) Composite Concrete. If located in sidewalk or other paved surface, the handhole shall be constructed with a portland cement concrete collar around the perimeter of the handhole. The collar shall be 3 in. (75 mm) wide and the depth shall be equal to the adjacent paved surface. Preformed joint filler of 1/2 in. (13 mm) thickness shall be placed between new concrete and existing concrete.

814.04 Backfilling. Backfill shall be placed and compacted in 6 in. (150 mm) lifts.

Any backfilling necessary under a pavement, paved shoulder, sidewalk, or within 2 ft (600 mm) of the pavement edge shall be made with sand or stone screenings. The backfill shall be compacted according to Article 550.07.

814.05 Cleaning. The handhole shall be thoroughly cleaned of any accumulation of silt, debris, or foreign matter of any kind.

814.06 Basis of Payment. This work will be paid for at the contract unit price per each for HANDHOLE, HEAVY-DUTY HANDHOLE, or DOUBLE HANDHOLE, of the material type when specified.

SECTION 815. GULFBOX JUNCTION

815.01 Description. This work shall consist of furnishing and installing a gulfbox junction.

815.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate (Note 1)	1004.01
(b) Portland Cement Concrete (Note 2)	1020
(c) Gulfbox Junction	1088.07

Note 1. Gradation CA 6 shall be used.

Note 2. Class SI concrete shall be used.

CONSTRUCTION REQUIREMENTS

815.03 Installation. The location of the gulfbox junction shall be excavated so that the top of the gulfbox is set flush with the sidewalk or paved surface. When installed in earth shoulder away from the pavement edge, the top surface of the gulfbox shall be 1 in. (25 mm) above the finished grade. The excavation shall be deep enough to accommodate the depth of the box and the base.

When the gulfbox is to be constructed over existing conduit, the conduit shall be cut, 90 degree elbows installed, and the box constructed as shown on the plans.

- (a) Cast Iron Gulfbox. The base shall be constructed of 6 in. (150 mm) of concrete placed at the bottom of the excavation. The concrete shall be placed around the conduits and the conduits shall protrude approximately 1/2 in. (13 mm) above the concrete surface.

The casting shall be secured by setting the bottom flange into the concrete surface 1/2 to 3/4 in. (13 to 20 mm) while the concrete is still plastic and then trowel the surface smooth. Any piping slots in the sides shall be plugged.

The remaining excavation shall be backfilled with suitable material.

- (b) Composite Concrete Gulfbox. The base shall be constructed of 6 in. (150 mm) of coarse aggregate placed at the bottom of the excavation. The conduits shall protrude approximately 1 in. (25 mm) above the coarse aggregate.

The gulfbox shall be set on this base.

The remaining excavation shall be backfilled with coarse aggregate.

If located in sidewalk or other paved surface, the gulfbox shall be set with a minimum of 3 in. (75 mm) of concrete placed on each side of the gulfbox. Preformed joint filler of 1/2 in. (13 mm) thickness shall be placed between new concrete and existing concrete.

815.04 Basis of Payment. This work will be paid for at the contract unit price per each for GULFBOX JUNCTION, of the kind of material when specified.

LIGHTING

WIRE AND CABLE

SECTION 816. UNIT DUCT

816.01 Description. This work shall consist of furnishing and installing preassembled cable in coilable nonmetallic conduit (unit duct), complete with all splicing, identifications, and terminations.

816.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Unit Duct	1066.01
(b) Coilable Nonmetal Conduit	1088.01(c)
(c) Conductors (Note 1)	1066.02
(d) Cable Insulation	1066.03
(e) Splicing and Termination of Electric Cable	1066.06
(f) Wiring Identification Markers	1066.07
(g) Electrical Tape	1066.08

Note 1. Copper conductors shall be used.

CONSTRUCTION REQUIREMENTS

816.03 Installation. Unit duct shall be installed according to Article 810.04 and the following. Use of the word conduit in Article 810.04 shall be construed to mean unit duct.

The unit duct shall be installed directly from the reels on which the unit duct was shipped, in continuous spans between terminal points. Splicing will only be permitted in pole handholes or junction boxes on bridge structures above grade.

Where unit duct passes through handholes or pull boxes, the polyethylene duct shall be cut open and the continuous, uncut and unspliced conductors exposed and looped within the handhole or pull box. The ends of the polyethylene duct must be sealed with duct sealant and mounted in the handhole to prevent entrance of moisture or contaminants.

When the unit duct is to be pulled, the pulling apparatus shall be attached to the duct and not to the cables. The pulling tension on the duct shall not exceed 550 lb (2.4 kN).

Unit duct extended to light poles shall be of a length sufficient for cable splices to be withdrawn a minimum of 18 in. (450 mm) out of pole handholes. The duct of the unit duct assembly shall extend a minimum of 12 in. (300 mm) into pole shafts or transformer bases.

Minimum bending radius for the installed unit duct assembly shall be no smaller than the manufacturer's recommended radius. Bends shall be made so that the duct will not be damaged or kinked and the internal diameter of the duct will not be effectively reduced. There shall not be more than the equivalent of four quarter bends between pull points and no bend greater than 90 degrees.

Immediately after placement, the cable ends shall be sealed to prevent entrance of moisture and contaminants, unless splicing or termination work is performed concurrently.

Where plowed, the unit duct shall be laid in place and the duct shall not be pulled through the length of the cut behind a bullet-nose mandrel or similar apparatus. Plowing operations shall be non-injurious to the duct.

Before final wire and cable connections are made, the Contractor shall demonstrate that all conductors within the unit duct are free to move.

When placed in a raceway, lubricating compounds shall be used where necessary to assure smooth installation.

816.04 Method of Measurement. The unit duct will be measured for payment in feet (meters) in place. Measurements will be made in straight lines between changes in direction and to the center of equipment and boxes. 3 ft (1 m) of extra unit duct will be allowed when terminating at a controller, light pole, or handhole. 1 ft (300 mm) of extra unit duct will be allowed at pull boxes, junction boxes, and similar locations.

The vertical distance of unit duct required for breakaway devices, barrier walls, concrete pedestals, etc., and the depth of any burial will be measured in feet (meters). Changes in direction shall assume perfect straight line runs, ignoring actual raceway sweeps.

816.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) installed for UNIT DUCT, 600V, of the number, size and type of conductors, and the size and type of duct specified.

SECTION 817. CABLE IN RACEWAY

817.01 Description. This work shall consist of furnishing and installing electric cables in raceways, complete with all splicing, identifications, and terminations.

817.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Conductors (Note 1)	1066.02
(b) Cable Insulation	1066.03
(c) Splicing and Termination of Electric Cable	1066.06
(d) Wiring Identification Markers	1066.07
(e) Electrical Tape	1066.08

Note 1. Copper conductors shall be used.

CONSTRUCTION REQUIREMENTS

817.03 Installation. Cable shall be installed without damaging the insulation.

Cable lubricant shall be used when pulling cables into conduits. The lubricant shall be non-injurious to conduits, conductors, insulations, or jackets.

Where a number of cables are trained through a box, manhole, or handhole, the cables shall be grouped by circuit where applicable and bundled using appropriate cable ties and supported to minimize pressure or strain on cable insulation.

Wire and cable extended to light poles shall be of a length sufficient for cable splices to be withdrawn a minimum of 18 in. (450 mm) out of pole handholes.

Wire and cable shall not be bent to a radius less than the manufacturer's recommended bending radius, either in permanent placement or during installation. Cable pulling apparatus shall have no sharp edges or protrusions which could damage cables or raceways.

The cable shall be installed directly from the reels on which the cable was shipped. Dragging or laying cable on the ground will not be permitted. The cable shall be installed in continuous spans between terminal points and splicing will only be permitted in pole handholes or junction boxes on bridge structures above grade.

Immediately after placement, the cable ends shall be sealed to prevent entrance of moisture and contaminants, unless splicing or termination work is performed concurrently.

817.04 Method of Measurement. The cable will be measured for payment in feet (meters) in place. Measurements will be made in straight lines between changes in direction and to the center of equipment and boxes. 3 ft (1 m) of extra cable will be allowed when terminating at a controller, light pole, or handhole. 1 ft (300 mm) of extra cable will be allowed at pull boxes, junction boxes, and similar locations.

The vertical distance of cable required for breakaway devices, barrier walls, concrete pedestals, etc., and the depth of any burial will be measured in feet (meters). Changes in direction shall assume perfect straight line runs, ignoring actual raceway sweeps.

817.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) installed for ELECTRIC CABLE IN CONDUIT, 600 V of the type, size, and number of conductors specified.

SECTION 818. AERIAL CABLE FOR LIGHTING

818.01 Description. This work shall consist of furnishing, installing and connecting aerial cable complete with all splicing, identifications, and terminations.

818.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Conductors (Note 1)	1066.02
(b) Aerial Cable Insulation	1066.03(a)(3)
(c) Aerial Cable Assembly	1066.04
(d) Splicing and Termination of Electric Cable	1066.06
(e) Wiring Identification Markers	1066.07
(f) Electrical Tape	1066.08

Note 1. Aluminum conductors shall be used.

CONSTRUCTION REQUIREMENTS

818.03 Installation. The luminaire connections to the aerial cable shall be made with listed parallel tap insulation piercing connectors. The connector shall be rated for 600 V.

When the installation is temporary, upon written request of the Contractor, the Engineer may permit temporary portions of the work to be wired with previously-installed (used) aerial cable of ampacity equivalent to the specified cable and of a type and condition approved by the Engineer. The cable shall be left in place for the duration of the need for temporary wiring.

In addition to the wiring of temporary equipment indicated, the Contractor shall furnish and install electric feeders and make necessary equipment modifications to connect the existing system(s) to the temporary system(s). Buck-Boost Transformer(s), when indicated on the plans, shall be of the voltage and KVA indicated (or otherwise as applicable for the circuit), dry type, suitable for outdoor installation.

818.04 Method of Measurement. The aerial cable will be measured in feet (meters) in place and will be taken as the length of the messenger wire. Measurements will be made in a straight line between changes in direction and to the centers of light standards and control cabinets. Sag of the aerial cable or vertical

cable will not be measured for payment. When the Engineer requests the used temporary cable be replaced with new, the new cable will be measured for payment.

Used aerial cable will not be measured for payment.

The rewiring to facilitate relocation of the cable due to staging or other construction requirements will not be measured for payment.

818.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for AERIAL CABLE WITH MESSENGER WIRE, of the number and size of conductors specified.

SECTION 819. RESERVED

LUMINAIRES

SECTION 821. ROADWAY LUMINAIRES

821.01 Description. This work shall consist of furnishing and installing a luminaire.

821.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Luminaire	1067
(b) Wire in the Pole	1066.09
(c) Fuseholders and Fuses	1065.01
(d) Lamps	1067.06
(e) Fasteners and Hardware	1088.03
(f) Lightning Protection	1065.02

CONSTRUCTION REQUIREMENTS

821.03 General. Each luminaire shall be installed according to the luminaire manufacturer's recommendations.

Luminaires which are pole mounted shall be mounted on site such that poles and arms are not left unloaded. Pole mounted luminaires shall be leveled/adjusted after poles are set and vertically aligned before being energized. When mounted on a tenon, care shall be exercised to assure maximum insertion of the mounting tenon.

Each luminaire ballast and/or ballast arrangement shall be checked to assure compatibility with the project power system. When the luminaire has a multi-tap ballast, the tap shall be adjusted as necessary to assure a voltage match.

When the night-time check of the lighting system by the Engineer indicates that any luminaires are mis-aligned, the mis-aligned luminaires shall be corrected at no additional cost. Should the photometric results of the luminaire indicate, in the

judgement of the Engineer, a tilt adjustment is warranted, the adjustment shall be made at no additional cost.

No luminaire shall be installed before it is approved. Where independent testing is required, full approval will not be given until complete test results, demonstrating compliance with the specifications, have been reviewed and accepted by the Engineer.

Pole wiring shall be provided with the luminaire. Included with the pole wiring shall be a surge protector and fusing located in the handhole. Wire shall be trained within the pole or sign structure so as to avoid abrasion or damage to the insulation.

Pole wire shall be extended through the pole, pole grommet, luminaire ring, and any associated arm and tenon. The pole wire shall be terminated in a manner that avoids sharp kinks, pinching, pressure on the insulation, or any other arrangement prone to damaging insulation value and producing poor megger test results. Wires shall be trained away from heat sources within the luminaire. Wires shall be terminated so all strands are extended to the full depth of the terminal lug with the insulation removed far enough so it abuts against the shoulder of the lug, but is not compressed as the lug is tightened.

When installing the lamp or performing any other activity that requires opening of the optical assembly, care shall be exercised to avoid touching the reflector or allowing contaminants to enter the assembly. Each lamp and lens shall be free of all dirt, smudges, etc. Should the reflector or refractor require cleaning, a mild soap or non-abrasive detergent, containing no chlorinated or aromatic hydrocarbons, shall be used and then rinsed clean with cold water and wiped dry.

821.04 Conventional Pole Installation. Horizontal mount luminaires shall be installed in a level, horizontal plane, with adjustments as needed to insure the optics are set perpendicular to the traveled roadway.

When the pole is bridge mounted, a minimum size stainless steel 1/4-20NC set screw shall be provided to secure the luminaire to the mast arm tenon. A hole shall be drilled and tapped through the tenon and luminaire mounting bracket and then fitted with the screw.

821.05 Highmast Installation. Luminaires having asymmetrical photometric distributions shall be carefully oriented with respect to the roadway as indicated on the plans and as directed by the Engineer. The Contractor shall confirm all luminaire orientations with the Engineer prior to installation.

For horizontal mounts having rotating optical assemblies, after the orientation of each mast arm tenon is inspected and approved by the Engineer, the position shall be permanently marked in a manner acceptable to the Engineer. The luminaire shall then be leveled to the plane of the luminaire ring.

When the luminaire position and orientation has been confirmed and approved by the Engineer, the luminaire shall be anchored with a minimum size 1/4-20NC stainless steel set screw installed through tapped holes in the tenon and mounting bracket of the luminaire. Counterweights on un-used tenons shall be mounted in a similar manner.

Pre-installed wire on the tower ring shall have the ends of each wire capped at the tenon with butt type crimp-connectors for un-used tenons. The wires shall then be re-inserted into the tenon end and the tenon end shall be capped.

821.06 Underpass Installation. When attached directly to a structure, the underpass luminaire shall have 1 in. (25 mm) stainless steel spacers installed between the luminaire and the structure.

When specified, an aluminum underpass luminaire numbering decal bracket for each underpass luminaire shall be installed as shown on the plan. The bracket shall be large enough to accommodate the identification and shall be mounted on the pier or retaining wall from which the luminaires are electrically fed as directed by the Engineer.

When suspended, the underpass luminaire shall be installed 1 in. (25 mm) above the lowest underpass beam and shall be mounted parallel to the plane of the roadway, taking into consideration the applicable grade and superelevation of the traveled lanes. Vibration dampening assemblies shall be used and sized to the weight and shape of the underpass luminaire. All mounting hardware, except the vibration dampers, shall be stainless steel.

The underpass luminaire shall include, from the junction box mounted at the abutment to the luminaire(s), all conduit, fittings, attachment hardware, cable, and stainless steel junction boxes needed to complete the branch circuit.

821.07 Sign Lighting Installation. Each luminaire shall be mounted on the sign walkway structure with stainless steel hardware and with at least three points of attachment. The mounted luminaire or mounting hardware shall not extend above the bottom of the sign or below the bottom of the walkway support.

The center-to-center spacing of the luminaires will be determined by the Engineer. The end sections shall not exceed one-half the spacing between luminaires.

The mounting shall provide the correct position of the luminaire as recommended by the manufacturer and shall be able to withstand assigned loading according to AASHTO. The sign lighting installation shall include, from the sign truss handhole to the luminaire, all aluminum conduit, fittings, attachment hardware, cable, and a stainless steel disconnect switch with lockable exterior handle mounted within reach from the walkway.

Disabling brightness shall be shielded from traffic approaching either the front or back of the sign.

821.08 Basis of Payment. This work will be paid for at the contract unit price per each for LUMINAIRE, of the lamp type, mount type, and wattage specified, UNDERPASS LUMINAIRE, of the wattage and lamp type indicated; or SIGN LIGHTING, of the lamp type specified.

SECTION 822. NAVIGATION OBSTRUCTION WARNING LUMINAIRES

822.01 Description. This work shall consist of furnishing and installing a navigation obstruction warning fixture complete with all supports, hardware, wiring, and connections to the structure or pole, and appurtenant mounting accessories.

822.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Waterway Obstruction Warning Luminaire	1067.07(a)
(b) Aviation Obstruction Warning Luminaire	1067.07(b)
(c) Fuseholders and Fuses	1065.01
(d) Lamps	1067.06
(e) Transformer, General Purpose	1068.02

CONSTRUCTION REQUIREMENTS

822.03 Installation. Mounting of the luminaire shall be as recommended by the luminaire manufacturer in such a manner that they clear all obstacles when retrieved for maintenance and relamping.

822.04 Basis of Payment. This work will be paid for at the contract unit price per each for WATERWAY OBSTRUCTION WARNING LUMINAIRE or AVIATION OBSTRUCTION WARNING LUMINAIRE, of the type indicated.

CONTROLLERS

SECTION 825. LIGHTING CONTROLLER

825.01 Description. This work shall consist of furnishing and installing an electrical controller.

825.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete (Note 1)	1020
(b) Lighting Controller	1068.01
(c) Transformer, General Purpose	1068.02
(d) Lightning Protection	1065.02

Note 1. Class SI concrete shall be used.

CONSTRUCTION REQUIREMENTS

825.03 Installation. The lighting controller installation shall be according to the details, location, and orientation shown on the plans.

A 4 in. (100 mm) thick portland cement concrete work pad, not less than 48 x 48 in. (1.2 x 1.2 m) shall be provided in front of the cabinet, except where the cabinet faces an adjacent sidewalk.

All conduit entrances into the lighting controller shall be sealed with a pliable waterproof material.

- (a) **Controller Mounted on Concrete Foundation.** The Contractor shall confirm the orientation of the lighting controller, and its door side, with the Engineer, prior to installing the foundation. A portland cement concrete foundation shall be constructed to the details shown on the plans.

The lighting controller enclosure or pedestal shall be set plumb and level on the foundation. It shall be fastened to the anchor rods with hot-dipped galvanized or stainless steel nuts and washers. Foundation mounted lighting controllers shall be caulked at the base with silicone.

Where the controller has a metal bottom plate, the plate shall be sealed with a rodent and dust/moisture barrier.

- (b) **Controller Mounted on Pole.** The lighting controller enclosure shall be mounted to the pole as shown on the plans. Aluminum brackets designed for pole mounting shall be used. Enclosures greater than 26 in. (650 mm) in height shall have stiffener plates on both top and bottom of the rear wall for mounting brackets. All mounting hardware shall be stainless steel.
- (c) **Controller Mounted on Wall.** The lighting controller enclosure shall be mounted to the wall with stainless steel fasteners as indicated in the plans. Stainless steel mounting brackets designed for wall mounting shall be used.

825.04 Grounding. Grounding shall be according to Section 806.

825.05 Basis of Payment. This work will be paid for at the contract unit price per each for LIGHTING CONTROLLER, of the enclosure and control type specified.

SECTION 826. NAVIGATION OBSTRUCTION LIGHTING CONTROLLER

826.01 Description. This work shall consist of furnishing and installing an electrical controller for navigation obstruction lighting.

826.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete (Note 1)	1020
(b) Navigation Obstruction Lighting Controller	1068.03
(c) Transformer, General Purpose	1068.02
(d) Lightning Protection	1065.02

Note 1. Class SI concrete shall be used.

CONSTRUCTION REQUIREMENTS

826.03 Installation. Installation shall be according to Article 825.03.

826.04 Grounding. Grounding shall be according to Section 806.

826.05 Basis of Payment. This work will be paid for at the contract unit price per each for NAVIGATION OBSTRUCTION LIGHTING CONTROLLER, of the enclosure and control type specified.

SECTION 827. TRANSFORMER, GENERAL PURPOSE

827.01 Description. This work shall consist of furnishing a dry type transformer, wiring, conduit and mounting hardware, and installing it at the location shown on the plans or as designated by the Engineer.

827.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Transformer, General Purpose	1068.02
(b) Electrical Raceway Materials	1088.01
(c) Wire and Cable	1066
(d) Splicing and Termination of Electric Cable	1066.06
(e) Fasteners and Hardware	1088.03

CONSTRUCTION REQUIREMENTS

827.03 Installation. General purpose transformers may be mounted inside a control cabinet, on a sign truss, and on a bridge structure requiring different mounting hardware. All material required to complete the installation shall be included. The transformer enclosure shall be NEMA 3R or 4X and may be stainless steel as shown on the plans. It shall be solid dielectric, air cooled, and of a type (i.e., buck/boost) as specified. The plans shall identify size in KVA as well as primary and secondary voltages. Air movement must be considered for mounting inside a junction box or other confined space.

827.04 Basis of Payment. This work will be paid for at the contract unit price per each for TRANSFORMER, GENERAL PURPOSE, of the size and type specified.

POLES AND TOWERS

SECTION 830. LIGHT POLES

830.01 Description. This work shall consist of furnishing and installing a light pole complete with an arm(s), when specified, and all hardware and accessories required for the intended temporary or permanent use of the pole.

830.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Light Poles	1069.01-1069.05
(b) Mounting Pad	1069.07
(c) Pole/Unit Identification	1069.06

CONSTRUCTION REQUIREMENTS

830.03 Installation. The light pole shall be set plumb on the foundation without the use of shims, or washers for leveling. On bridge parapet walls, a vibration mounting pad shall be installed between the foundation leveling plate and the light pole.

The handhole shall be located such that workers accessing the handhole shall face oncoming traffic directly or located on the back side of the pole facing the roadway. On bridge parapet walls, the access handhole shall be oriented facing the roadway.

Arms shall be set at right angles to the centerline of the pavement. Poles shall not be left in place without arm(s) and luminaire(s).

The Contractor shall be responsible to furnish pole mounting equipment that is of adequate strength and compatible for the pole it supports. This shall include, but not be limited to, the foundation, breakaway device (when specified), anchor rods, and hardware.

Lighting unit identification numbers shall be installed before the lighting unit is energized.

- (a) **Foundation Mounted Poles.** The Contractor shall avoid contact of dissimilar metals in erecting the pole on its foundation and/or breakaway device. Any concern of trapped moisture or potential corrosion cell shall be resolved to the satisfaction of the Engineer.
- (b) **Direct Embed Fiberglass Pole.** The depth of a direct embed fiberglass pole in the ground shall not be less than ten percent of the pole length plus 2 ft (600 mm) with a minimum of 6 ft (1.8 m). Direct embed poles shall be raked 1 ft (300 mm). Care shall be taken to get the shear plane of the pole at groundline for breakaway poles. Backfill shall be tamped and compacted around the pole in 6 in. (150 mm) lifts.
- (c) **Wood Pole.** Poles shall be stored and handled according to ANSI O5.1.

The depth of the pole in the ground shall not be less than ten percent of the pole length plus 2 ft (600 mm) with a minimum of 6 ft (1.8 m). The poles shall be raked 1 ft (300 mm). Backfill shall be tamped and compacted around the pole in 6 in. (150 mm) lifts.

Pole guying shall be provided where indicated on the plans, at every dead end pole, and at any pole having non-offsetting cable support stresses.

830.04 Temporary Installation. Wood poles used for a temporary lighting installation may be previously used poles as approved by the Engineer. The poles shall be in good condition and shall be according to the applicable ANSI requirements for sweep, crook, defects, and mechanical damage. Poles deemed unacceptable by the Engineer shall be removed from the jobsite.

830.05 Basis of Payment. This work will be paid for as follows.

- (a) Wood poles will be paid for at the contract unit price per each for LIGHT POLE, WOOD, of the length, class and arm (quantity and length) type specified.
- (b) All other light poles will be paid for at the contract unit price per each for LIGHT POLE, of the material type, mounting height, and arm (quantity and length) type specified.

When breakaway devices are specified, the devices will be measured and paid for separately according to Articles 838.04 and 838.05.

SECTION 831. RESERVED

SECTION 832. RESERVED

SECTION 833. RESERVED

SECTION 834. RESERVED

SECTION 835. LIGHT TOWER

835.01 Description. This work shall consist of furnishing and installing a light tower complete with lowering device, and all hardware and accessories required for a complete operating unit.

835.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Light Tower	1069.08
(b) Pole/Unit Identification	1069.06
(c) Transformer	1068.02

CONSTRUCTION REQUIREMENTS

835.03 Submittals and Certifications. Shop drawings, product data, and certifications shall be submitted to the Engineer for approval. The submitted

information shall be complete and shall include information relative to all specified requirements suitable for verification of compliance.

In general, light tower submittal information shall be dated, current, project specific, identified as to the project, and shall include the following.

- (a) Dimensioned shaft drawings and details.
- (b) Shaft design calculations, including Registered Engineer Certification.
- (c) Shaft material data, including finish information.
- (d) Welding details and procedures.
- (e) Letter of intent to provide specified weld inspection reports.
- (f) Confirmation of coordination between anchor rod supplier and tower manufacturer for adequacy of anchor rod assembly.
- (g) Manufacturer's recommended installation procedures.
- (h) Letter of intent to provide manufacturer's representative during installation and to provide specified installation certification.
- (i) Lowering device data, including electrical details.

835.04 Shipment and Installation. The light tower, luminaire ring, etc., and hardware shall be packaged during shipment to protect all surfaces from being scratched, marred, chipped, or damaged in any way. Prior to installation, the tower and all its components will be inspected by the Engineer and any parts found to be damaged or defective shall be replaced. Any minor damage to a completely painted light tower surface shall be touched up in a professional manner as approved by the paint manufacturer.

The tower shall be set plumb on the foundation and fastened to the anchor rods with double nuts and washers. Flat washers shall be installed below and above the base plate of the tower. Locknuts with nylon or steel inserts shall be installed on top of the top nut. The nuts shall be tightened in compliance with torque specifications recommended by the manufacturer of the tower.

The space between the finished top of the foundation and the bottom of the base plate of the tower shall be enclosed with a metal screen according to Article 733.07. The screen shall be carefully positioned to eliminate small gaps that could allow the entry of rodents. Grouting shall not be used to enclose the above described space.

The light tower shall be straight and centered on its longitudinal axis, under no-wind conditions, so, when examined with a transit from any direction, the deviation from the normal shall not exceed 1/8 in. in 3 ft (3 mm in 1 m) within any 5 ft (1.5 m) of height, with total deviation not to exceed 3 in. (75 mm) from the vertical axis through the center of the tower base.

835.05 Basis of Payment. This work will be paid for at the contract unit price per each for LIGHT TOWER, of the mounting heights, luminaire mounting positions, and finish specified.

The concrete foundation and luminaires will be paid for according to Sections 837 and 821, respectively.

FOUNDATIONS AND BREAKAWAY DEVICES

SECTION 836. POLE FOUNDATION

836.01 Description. This work shall consist of constructing or furnishing and installing a light pole foundation.

836.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Anchor Rods	1070.02
(c) Light Pole Foundation, Metal	1070.01
(d) Fine Aggregate	1003.04
(e) Grout (Note 1)	1024.01

Note 1. The grout mixture shall be one part cement and two parts sand mixed with water.

CONSTRUCTION REQUIREMENTS

836.03 Installation. Foundations installed within the clear zone (unless behind guardrail) shall not protrude more than 4 in. (100 mm) above the finished grade within a 5 ft (1.5 m) chord across the foundation, with anchor rods and breakaway device included. If foundation heights, including anchor rods and fractured breakaway device extend beyond these specified limits, the foundation shall be replaced.

- (a) Drilled Shaft Foundations. Drilled shaft foundations shall be constructed according to Section 516 and the following.

The submittal requirements as stated in Article 516.04 shall not apply and the entire length of the drilled shaft shall be vibrated.

Grounding electrodes shall be according to Section 806.

The raceway and full length anchor rods shall be properly positioned and secured in the augered hole prior to placing the concrete. The bend radius of the anchor rods shall be at least four times the rod diameter.

The wiring window shall be perpendicular to the roadway. After installation of cable, voids within the wiring window shall be filled with fine aggregate.

The top of the foundation shall be constructed level. A liner or form shall be used to produce a uniform smooth side to the top of the foundation. The depth of the form shall be as shown on the plans.

The foundation form shall remain undisturbed for at least 24 hours after the concrete has been poured.

Concrete shall be cured before poles are installed.

When obstructions are encountered, the Contractor shall request to relocate the foundation. Any abandoned holes shall be backfilled to the satisfaction of the Engineer.

When rock is encountered, the foundation depth may be reduced 6 in. (150 mm) for every 12 in. (300 mm) of embedment in rock. The minimum depth of any foundation shall be 4.5 ft (1.4 m).

When the foundation depth is reduced to less than specified, the anchor rods shall be cut, threaded, and a steel plate of the diameter shown on the plans shall be installed on the bottom of the anchor rods 6 in. (150 mm) above the bottom of the excavated hole with 1 in. (25 mm) nuts.

(b) **Metal Foundations.** Metal foundations shall be installed in undisturbed soil.

The foundation shall be installed with its axis plumb. The light pole shall be installed plumb without the use of shims, grout, or other leveling devices.

Any voids within the metal screw-in foundation shall be filled with fine aggregate.

Wiring windows shall be oriented to be parallel to the roadway unless otherwise directed by the Engineer to achieve alignment with grade or to minimize bends in the feeder wiring into the foundation.

The Contractor shall use a torque indicating device to install metal foundations. A shear pin indicator or other Engineer approved method shall be used to insure the foundation is installed properly. A metal foundation shall not be installed to a torque which exceeds the manufacturer's maximum torque rating nor shall it be installed to an installation torque value of less than 3,500 ft lb (5,000 N m). Metal foundations that are not installed to full installation depth or do not achieve the minimum installation torque shall be removed and replaced with a concrete foundation at no additional cost to the Department.

Driven grounding electrodes will not be required when metal foundations are specified.

836.04 Method of Measurement. Concrete foundations will be measured for payment in feet (meters) in place. The length measured will be limited to that shown on the plans or authorized by the Engineer. Any offsets in the foundation will be

Art. 836.04 Pole Foundation
measured along the vertical and horizontal centerlines of the foundation without overlap.

Relocation of a foundation due to an obstruction and any shaft excavation to that point will not be measured for payment.

Excavation in rock will be measured for payment according to Article 502.12.

836.05 Basis of Payment. Concrete foundations will be paid for at the contract unit price per foot (meter) for LIGHT POLE FOUNDATION, of the diameter specified.

Metal foundations will be paid for at the contract unit price per each for LIGHT POLE FOUNDATION METAL, of the bolt circle, diameter, and length specified.

Excavation in rock will be paid for according to Article 502.13.

SECTION 837. LIGHT TOWER FOUNDATION

837.01 Description. This work shall consist of constructing a drilled shaft foundation for a light tower.

837.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete (Note 1)	1020
(b) Light Tower Anchor Rod Assembly	1070.03
(c) Fine Aggregate	1003.04
(d) Reinforcement Bars	1006.10(a)

Note 1. Class SI concrete shall be used for the concrete work pad and shall be cured according to Article 1020.13 under other incidental concrete.

CONSTRUCTION REQUIREMENTS

837.03 Installation. Drilled shaft foundations shall be constructed according to Section 516 and the following.

When obstructions are encountered, the Contractor shall request to relocate the foundation. Any abandoned holes shall be backfilled to the satisfaction of the Engineer.

Grounding electrodes shall be according to Section 806.

The anchor rod assembly may be factory fabricated with the reinforcing cage or it may be field assembled. The cage shall be hand tied, no tack welding will be allowed. Anchor rods shall sufficiently overlap with the rebar cage to develop their full holding strength. Full length anchor rods shall not be used unless approved by the Engineer.

The top of the foundation to 18 in. (450 mm) below grade shall be formed. The reinforcing cage, anchor rods, and wireway shall be accurately held in place by the form. The anchor rods shall be held plumb above the top of the foundation during concrete placement.

A permanent, concrete work pad shall be constructed as shown on the plans. This 36 x 36 x 8 in. (900 x 900 x 200 mm) pad shall be centered in front of the handhole and finished level.

After installation of cable, voids within the wiring window shall be filled with fine aggregate.

Concrete shall be cured before light towers are installed.

837.04 Method of Measurement. This work will be measured for payment in feet (meters) in place. The length measured will be limited to that shown on the plans or authorized by the Engineer.

Excavation in rock will be measured for payment according to Article 502.12.

837.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for LIGHT TOWER FOUNDATION of the diameter specified.

Excavation in rock will be paid for according to Article 502.13.

Obstruction mitigation or abandoned foundation excavations and backfill will be paid for according to Article 109.04.

SECTION 838. BREAKAWAY DEVICES

838.01 Description. This work shall consist of furnishing and installing a breakaway device on a pole foundation.

838.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Breakaway Devices	1070.04

CONSTRUCTION REQUIREMENTS

838.03 Installation. All entryway points created by the use of breakaway devices shall be permanently and completely sealed against rodent entry. This includes the pole base plate and foundation plate openings, elongated holes for anchor rods, the opening below the pole base plate, and the wiring windows in both steel and concrete foundations. Where breakaway couplings are used in conjunction with steel foundations, the Contractor shall match the plate sizes in order to seal out rodents between the foundation and pole base. Breakaway devices are not allowed on bridge parapets, barrier walls, or pedestrian conflict areas, and are not required behind guardrail. The Contractor shall verify that the loading of the pole, arm(s),

luminaire(s), and appurtenances does not exceed the capacity of the breakaway device.

- (a) **Transformer Base.** The transformer base shall be installed level and flush with the foundation without the use of leveling washers or shims according to the manufacturer's installation procedures. The anchor bolts shall be inserted full depth into the slotted holes of the transformer base. The transformer base shall be installed with access door aligned with light pole handhole. All nuts, bolts, washers, and lock washers required to complete the installation of the transformer base shall be included.
- (b) **Breakaway Couplings.** The breakaway couplings shall be coordinated to match anchor rod size. The breakaway coupling shall be installed on the anchor rod according to the manufacturer's recommendations. When used with a metal foundation, a nut shall be installed under the foundation plate on the stud bolt to prevent it from backing out of the breakaway coupling. The coupling installation shall not be used to level the pole base in lieu of a level foundation.

Bands to attach stainless steel screen shall not be tightened down on the breakaway couplings. The screen shall be tied back on itself and secured with stainless steel banding secured around the pole base plate and foundation top plate.

838.04 Method of Measurement. Transformer bases used for breakaway devices will be measured for payment as each, for each transformer base used.

Breakaway couplings used for breakaway devices will be measured for payment as each, for each individual coupling used, not as a set of four.

838.05 Basis of Payment. This work will be paid for at the contract unit price per each for BREAKAWAY DEVICE, TRANSFORMER BASE, of the bolt circle indicated; or BREAKAWAY DEVICE, COUPLING WITH ALUMINUM SKIRT, COUPLING WITH FIBERGLASS SHROUD, or COUPLING WITH STAINLESS STEEL SCREEN.

REMOVAL, RELOCATION, AND TEMPORARY LIGHTING

SECTION 841. TEMPORARY LIGHTING REMOVAL

841.01 Description. This work shall consist of the disconnection and removal of the temporary lighting system.

CONSTRUCTION REQUIREMENTS

841.02 Removal. Removal shall include the removal of temporary poles (which may be wood, concrete, steel, or aluminum), aerial cable, and all associated apparatus and connections. This removal shall also include removal of all wiring and connections to the associated lighting controller. All equipment and material, except

for luminaires removed as part of this item, shall become property of the Contractor and shall be removed from the site.

All luminaires will be inspected by the Engineer. Non-operating or damaged luminaires shall be repaired or replaced in kind.

Luminaires shall be removed, boxed in new containers approved by the Engineer, and delivered and unloaded at a storage facility of the Department, as designated by the Engineer.

The void caused by the removal of the pole shall be backfilled with suitable excavated material approved by the Engineer. Backfill shall be deposited in uniform lifts not exceeding 6 in. (150 mm) thick loose measure and compacted.

Backfill material for areas in the subgrade of the proposed improvement, and for areas outside of the subgrade where the inner edge of the void is within 2 ft (600 mm) of the edge of the proposed pavement, curb, gutter, curb and gutter, stabilized shoulder or sidewalk shall be fine aggregate, gradation FA 6.

Disposal of surplus material shall be according to Article 202.03.

With the approval of the Engineer, the Contractor may partially remove the temporary lighting system after parts of the permanent lighting system are operational. Any modifications to the temporary system to keep the temporary lighting system and permanent lighting system operational shall be performed at no additional cost to the Department.

841.03 Method of Measurement. Units will be measured for payment as each on a per pole basis, regardless of pole material, mounting height, the number and type of mast arm(s), luminaires and other appurtenant items attached thereto.

841.04 Basis of Payment. This work will be paid for at the contract unit price per each for REMOVAL OF TEMPORARY LIGHTING UNIT.

SECTION 842. REMOVAL OF LIGHTING UNITS

842.01 Description. This work shall consist of the removal and disposal of existing light units and their foundations.

CONSTRUCTION REQUIREMENTS

842.02 General. No removal work will be permitted without approval from the Engineer. Removal shall start as soon as the temporary lighting or permanent lighting, as applicable, is placed in approved operation. An inspection and approval by the Engineer will take place before any associated proposed permanent or temporary lighting is approved for operation.

842.03 Removal of Lighting Units. Any damage resulting from the removal and/or transportation of the lighting luminaire and associated hardware, shall be

repaired or replaced in kind. The Engineer will be the sole judge to determine the extent of damage and the suitability of repair and/or replacement.

The removal of pole mounted luminaries shall include the pole, breakaway device, arms, luminaries, and associated hardware and appurtenances.

Abandoned underground electric cables shall be removed with conduit and duct to a depth of 1 ft (300 mm) below ground level and the hole shall be backfilled. Cables in a unit duct may be removed from the duct and become the property of the Contractor. The empty duct shall be removed to 1 ft (300 mm) below ground level and the hole backfilled.

The removal of underpass and sign luminaries shall include all associated conduit, wire, junction boxes, hardware, and appurtenant materials.

Conduit hangers, straps, and supports shall be removed from bridge steel as directed by the Engineer. All open conductors and porcelain insulators shall be removed with the conduit system. Where the conduit system is removed from parapet walls and other concrete surfaces, the Contractor shall cut off the anchor device 1 in. (25 mm) below the surface of the concrete, and fill all voids with portland cement concrete mortar, making a smooth finish to the concrete surface.

Unprotected bridge steel which is exposed by the removal of the conduit system shall be touched up using a paint and procedure approved by the Engineer.

- (a) Removal of Lighting Unit, No Salvage. When indicated, poles, mast arms, luminaries, and all associated hardware and appurtenances shall become the property of the Contractor and shall be disposed of according to Article 202.03.
- (b) Removal of Lighting Unit, Salvage. When indicated, poles, mast arms, luminaries, and all associated hardware and appurtenances shall remain the property of the Department and shall be delivered to a Department facility within the District and unloaded and stacked there, as directed by the Engineer. Wood blocking, banding, or other appurtenant items required for proper stacking and protection shall be included.

Luminaires shall be removed, boxed in new containers, approved by the Engineer, and delivered to a Department facility, as designated by the Engineer.

842.04 Removal of Pole Foundation. Concrete foundations shall be removed to at least 2 ft (600 mm) below grade, with removed material disposed of according to Article 202.03. The removal shall extend deeper where required to facilitate roadway construction at no additional cost to the Department. Underground conduits and cables shall be separated from the foundation at 2.5 ft (750 mm) below grade and shall be abandoned or re-used as indicated.

Where light poles are removed from retaining or parapet walls, the Contractor shall cut off the anchor rods and conduit stub-ups 1 in. (25 mm) below the wall surface and fill all voids with portland cement concrete mortar making a smooth surface to match the shape of the wall.

Existing steel helix foundations shall be removed and cleaned to expose the foundation for inspection by the Engineer. Those foundations deemed not reusable by the Engineer shall become the property of the Contractor and shall be disposed of according to Article 202.03. Those foundations deemed re-usable by the Engineer shall be thoroughly cleaned (inside and outside) and delivered to a Department storage facility and unloaded and stacked there as directed by the Engineer.

The void caused by the removal of the foundations shall be backfilled according to Article 841.02.

842.05 Method of Measurement. Each lighting unit which is removed and delivered to a Department storage facility, or disposed of as indicated, will be counted as a unit for payment.

842.06 Basis of Payment. Removal of lighting units will be paid for at the contract unit price per each for REMOVAL OF LIGHTING UNIT, SALVAGE or REMOVAL OF LIGHTING UNIT, NO SALVAGE.

Foundation removal will be paid for at the contract unit price per each for REMOVAL OF POLE FOUNDATION.

SECTION 843. REMOVAL OF NAVIGATIONAL OBSTRUCTION WARNING LIGHTING

843.01 Description. This work shall consist of removing the existing bridge navigation obstruction warning lighting. This navigation lighting shall include fixtures installed for river navigation and, where applicable fixtures installed for air navigation.

CONSTRUCTION REQUIREMENTS

843.02 Removal of Navigation Obstruction Fixtures. No removal work will be permitted without approval from the Engineer. Navigation lighting must remain operational throughout the project according to the FAA and Coast Guard requirements and as directed by the Engineer. An inspection and approval by the Engineer will take place before any proposed permanent or temporary lighting is approved for operation.

Existing fixtures to be removed shall include the fixture, fixture housing, mounting devices, flanges, nipples, relay boxes, junction boxes, support arms and arm lifting devices, counter balance and weights, wiring, conduit, electrical devices, and all other fixture appurtenances as directed by the Engineer.

Removal of abandoned electric cables and raceways shall be according to Article 842.03.

Any fixtures or fixture components which the Engineer designates as salvage shall be removed, boxed in new containers, approved by the Engineer, and delivered and unloaded at a storage facility of the Department, as designated by the Engineer. Wood blocking, banding, or other appurtenant items required for proper stacking shall

Art. 843.02

Relocate Lighting Units

be included. Materials that are not salvaged shall become the property of the Contractor and shall be disposed of according to Article 202.03.

Any damage resulting from the removal and/or transportation of the lighting fixtures and associated hardware that are to be salvaged, shall be repaired or replaced in kind. The Engineer will determine the extent of damage and the suitability of repair and/or replacement.

843.03 Basis of Payment. This work will be paid for at the contract lump sum price for REMOVAL OF NAVIGATION OBSTRUCTION WARNING LIGHTING SYSTEM or at the contract unit price per each for REMOVAL OF NAVIGATION OBSTRUCTION WARNING LIGHTING UNIT.

SECTION 844. RELOCATE LIGHTING UNITS

844.01 Description. This work shall consist of removing an existing lighting unit and reinstalling temporary pole and/or lighting unit on a proposed foundation in locations as designated by the Engineer.

844.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Pole/Unit Identification	1069.06
(b) Fuseholders and Fuses	1065.01

CONSTRUCTION REQUIREMENTS

844.03 Lighting Unit. Lighting units shall be removed and reinstalled as follows.

- (a) Removal. The existing lighting unit shall be disconnected and removed from the existing foundation by removing the anchor rod nuts and lifting the lighting unit from the foundation.

Any damage sustained to the lighting unit during removal operations shall be repaired, or replaced in kind, to the satisfaction of the Engineer.

- (b) Reinstallation. The lighting unit shall be installed immediately on the proposed foundation. The electric cables shall be connected to power supply cables so the reinstalled lighting unit becomes operational the same evening without interruption. Temporary wiring will be permitted at the discretion of the Engineer.

When a conduit or duct extension is required, the conduit and/or duct may be spliced and a new span of cable shall be installed. The Engineer will inspect all conduit and/or duct splices before backfilling.

The existing pole wire shall be preserved and reconnected to the proposed underground wiring. The space between the finished top of the foundation

and the base plate of the pole shall be enclosed to prevent the entry of rodents in a manner approved by the Engineer.

The anchor rod cover and handhole covers of the lighting unit shall be removed and reinstalled. If during removal, the screws holding the cover break, a hole in the pole base shall be drilled and threaded to accept a new screw. The screws shall be 1/4 in. (6 mm) 20 stainless steel with anti-seize compound applied.

The mast arm and/or luminaire may be removed and reinstalled as a unit, at the option of the Contractor, with the approval of the Engineer. No additional compensation will be paid for these operations.

Luminaire Circuit Identification. Each lighting unit which is to be relocated under this item shall be checked during the preconstruction inspection for complete circuit identification. Any damage to the identification occurring prior to final acceptance shall then be repaired or replaced under this item, in conformance with the specifications, at no additional cost to the Department. The existing circuit identification and the identification shown on the plans shall be compared and where the existing identification must be changed to conform with the plans, the removal and replacement of identification shall be included in this item.

844.04 Light Towers. This work shall be according to Article 844.03 and the following.

The space between the finished top of the foundation and the bottom of the base plate of the tower shall be enclosed with a metal screen according to Article 733.07. The screen shall be carefully positioned to eliminate small gaps that could allow the entry of rodents. Grouting shall not be used to enclose the above described space.

The light tower shall be straight and centered according to Article 835.04.

844.05 Wood Poles. Wood pole removal, reinstallation, and luminaire circuit identification shall be as follows.

- (a) **Removal and Reinstallation.** The temporary lighting unit shall be installed immediately at the new location. The electric cables shall be connected to power supply cables so the reinstalled temporary light unit becomes operational the same evening without interruption. If the existing electric cables are not of sufficient length to make the new connection, a new continuous span of electric cables, of equal or better quality, shall be installed at no additional cost.

Any damage sustained to the temporary light unit during removal operations shall be repaired, or replaced in kind, to the satisfaction of the Engineer.

When a temporary lighting unit or pole is not in conflict with the proposed construction, but is in conflict with the Contractor's proposed sequence of operations, or the relocation is for the Contractor's convenience, relocation of said temporary lighting unit will be at the Contractor's option and expense.

The Contractor shall obtain the Engineer's approval before any pole or unit is relocated.

If the Engineer determines a given temporary lighting unit's pole setting has deteriorated to such an extent that the pole poses a safety hazard, the temporary lighting unit shall be reset in or near the same location.

- (b) Luminaire Circuit Identification. Each pole which is to be relocated shall be checked during the preconstruction inspection for complete circuit identification and corrected according to Article 1069.06.

Any damage to the identification occurring prior to final acceptance shall be repaired or replaced by the Contractor according to the specifications.

844.06 Method of Measurement. Relocation of lighting units, light towers, or temporary wood poles will be measured for payment as each.

If the Engineer determines a given temporary lighting unit's pole setting has deteriorated to such an extent that the pole poses a safety hazard, the temporary lighting unit will be measured for payment as each. Resetting of the pole will not be paid for if the pole setting has been weakened by construction operations.

844.07 Basis of Payment. This work will be paid for at the contract unit price per each for RELOCATE EXISTING LIGHTING UNIT, of the type specified; RELOCATE EXISTING LIGHT TOWER; or RELOCATE EXISTING WOOD POLES.

SECTION 845. REMOVAL OF LIGHTING CONTROLLER

845.01 Description. This work shall consist of the removal and disposal of existing electric service installation, lighting controller, and associated foundations.

CONSTRUCTION REQUIREMENTS

845.02 General. No removal work shall be permitted without approval from the Engineer. Abandoned underground electric cables shall be removed with conduit and duct to a depth of 1 ft (300 mm) below ground level and the hole backfilled. Cables in unit duct may be removed from the duct and become property of the Contractor.

Any removal work involving facilities owned by the electric utility shall be coordinated by the Contractor to insure the utility is properly notified and (if necessary) present while the removal work is being done. The Contractor shall insure that the removal work is disconnected from the utility's service equipment in a manner which is in compliance with the requirements of the utility.

845.03 Removal of Electric Service Installation. This work shall consist of the removal and satisfactory disposal of the wood pole and weatherhead or underground pedestal, grounding electrode, meter base, disconnect, conduit, wiring, and other miscellaneous items associated with an electric service installation.

845.04 Removal of Lighting Controller. This work shall consist of the removal and satisfactory disposal of the lighting controller cabinet, enclosed electrical equipment, and all other miscellaneous items associated with a lighting controller.

845.05 Removal of Lighting Controller Foundation. Concrete foundations shall be removed to at least 2 ft (600 mm) below grade with removed material disposed of according to Article 202.03. The removal shall extend deeper where required to facilitate roadway construction. Underground conduits and cables shall be separated from the foundation at 2.5 ft (750 mm) below grade and shall be abandoned or reused as indicated. The grounding electrode shall be removed or cut off to the same depth as the concrete.

Existing steel helix foundations shall be removed and disposed of according to Article 842.04.

The void caused by the removal of the foundations shall be backfilled according to Article 841.02.

845.06 Basis of Payment. Removal of lighting controllers will be paid for at the contract unit price per each for REMOVAL OF LIGHTING CONTROLLER.

Removal of electric service installations will be paid for at the contract unit price per each for REMOVAL OF ELECTRIC SERVICE INSTALLATION.

Removal of lighting controller foundations will be paid for at the contract unit price per each for REMOVAL OF LIGHTING CONTROLLER FOUNDATION.

TRAFFIC SIGNALS

MAINTENANCE

SECTION 850. MAINTENANCE OF EXISTING TRAFFIC SIGNAL INSTALLATION

850.01 Description. This work shall consist of maintaining an existing traffic signal installation that has been designated to remain in operation during construction.

850.02 Procedure. The energy charges for the operation of the traffic signals will be paid for by the Department or the local agency.

At least one week prior to beginning construction within 400 ft (125 m) of the signalized intersection, the Contractor shall conduct a signal inspection with a representative of the agency responsible for the signal maintenance. The signal inspection shall reveal defective existing traffic signal items such as inductive loop detectors, lead-in cable, detector loop, interconnect cable, and so forth, and the Contractor shall not be held responsible for these items. In case the Contractor fails to contact the signal maintaining agency for the signal inspection, the Contractor shall be held responsible for all the signal items remaining defective at the completion of the construction.

The Contractor shall become responsible for the maintenance of the existing signalized intersection at a date mutually agreed upon between the Contractor and the signal maintaining agency representative, but no later than the beginning of construction by the Contractor within 400 ft (125 m) of the intersection. The Contractor's signal maintenance responsibility shall cease upon the issuance of a Signal Acceptance Notice by the Engineer.

850.03 Maintenance. The maintenance shall be according to Article 801.11 and the following.

The Contractor shall be responsible for the controller programming to provide for safe and efficient signal operation during construction. The Contractor may seek assistance from the maintaining agency personnel on the appropriate controller settings.

850.04 Basis of Payment. This work will be paid for at the contract unit price per each for MAINTENANCE OF EXISTING TRAFFIC SIGNAL INSTALLATION. Each intersection will be paid for separately.

SECTION 851. PAINT EXISTING TRAFFIC SIGNAL EQUIPMENT

851.01 Description. This work shall consist of cleaning and painting the existing traffic signal equipment reused as part of the new traffic signal installation.

851.02 Materials. Materials shall be as specified in the contract.

CONSTRUCTION REQUIREMENTS

851.03 Cleaning. Prior to painting, the surfaces shall be thoroughly cleaned of all surface irregularities and foreign materials, so the prime and paint coatings will have a smooth finish.

851.04 Painting. After cleaning, one coat of primer shall be applied to all areas where the old paint has been removed or damaged. On surfaces where small areas of metal at closely spaced intervals are exposed, the primer shall consist of a complete coating. The surface of the signal equipment shall be painted as follows.

- (a) The signal housings, controller cabinet, signal posts (except bright aluminum posts), and brackets shall be painted with two coats of yellow.
- (b) The signal doors, visors, and metal backplates (except polycarbonate materials) shall be painted with two coats of dull (matte) black paint.
- (c) The steel mast arm assemblies and poles shall be painted with two coats of aluminum paint.

851.05 Method of Measurement. This work will be measured for payment as each. Each intersection will be considered one each.

851.06 Basis of Payment. This work will be paid for at the contract unit price per each for PAINT EXISTING TRAFFIC SIGNAL EQUIPMENT.

CONTROLLERS AND EQUIPMENT

SECTION 857. TRAFFIC ACTUATED CONTROLLER

857.01 Description. This work shall consist of furnishing and installing a traffic actuated solid state digital controller in the controller cabinet of the type specified with peripheral equipment.

857.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Traffic Actuated Solid State Digital Controller	1073.01
(b) Controller Cabinet and Peripheral Equipment	1074.03

CONSTRUCTION REQUIREMENTS

857.03 Installation. The traffic actuated controller shall be installed in a completely wired cabinet, with necessary connections for proper operation. The model and serial number of the controller shall be permanently affixed on the front or top of the controller housing and readily visible.

All conduit entrances into the controller cabinet shall be sealed with a pliable waterproof material. Electrical cables inside the controller cabinet shall be neatly trained along the base and back of the cabinet. Each conductor shall be connected individually to the proper terminal, and the spare conductors shall be insulated and bound into a neat bundle. Each cable shall be marked with identification meeting the approval of the Engineer and recorded on a copy of the plans for the intersection and submitted to the Engineer.

The traffic actuated controller shall provide the NEMA eight phase dual ring operation for the phase designation diagram shown on the plans and the preemption sequence of operation, when shown on the plans. A print out of all controller settings including coordination and preemption shall be provided to the Engineer.

857.04 Basis of Payment. This work will be paid for at the contract unit price per each for FULL-ACTUATED CONTROLLER AND CABINET or RAILROAD, FULL-ACTUATED CONTROLLER AND CABINET, of the type specified. The transceiver shall be furnished with the controller only when specified as a separate pay item on the plans.

SECTION 858. FLASHER CONTROLLER

858.01 Description. This work shall consist of furnishing and installing a flasher controller and cabinet.

858.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Flasher Controller	1073.02

CONSTRUCTION REQUIREMENTS

858.03 Installation. The flasher controller shall be installed according to the details shown on the plans.

858.04 Basis of Payment. This work will be paid for at the contract unit price per each for FLASHER CONTROLLER.

SECTION 859. TRANSCEIVER

859.01 Description. This work shall consist of furnishing and installing a transceiver with necessary connections for proper operation.

859.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Transceiver	1073.03

CONSTRUCTION REQUIREMENTS

859.03 Installation. The transceiver shall be connected to the communication interface panel. The transceiver shall be assigned a unique address in the master controller.

859.04 Basis of Payment. This work will be paid for at the contract unit price per each for TRANSCEIVER.

The interface panel, all necessary harnesses, and the programming of the controller and the master controller shall be included in this item.

SECTION 860. MASTER CONTROLLER

860.01 Description. This work shall consist of furnishing and installing a master controller with the necessary connections for proper operation.

860.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Master Controller	1073.04

CONSTRUCTION REQUIREMENTS

860.03 Installation. Installation of the master controller shall be as follows.

- (a) Telephone Service. The Contractor shall arrange with the telephone company to install a standard voice-grade dial-up telephone line. Any charges by the telephone company to provide initial service will be paid for according to Article 109.05.
- (b) System Set-up. The Contractor shall set up graphic displays and all software parameters, including compatible viewing and control capabilities from the remote monitor.
- (c) Housing and Cabinet. The model and serial numbers shall be affixed on the front of the housing and shall be readily visible. The master controller shall be installed in the same cabinet with a traffic signal controller. One circuit breaker rated at 10 A shall be provided.
- (d) Software. Based on the need, up to three complete sets of the latest edition of registered remote monitoring software with full manufacturer's support shall be furnished with each master controller. Each set shall consist of complete software on 3 1/2 in. (90 mm) floppy disks, and a bound set of manuals containing loading and operating instructions. The distribution of the software will be directed by the Engineer.

860.04 Basis of Payment. This work will be paid for at the contract unit price per each for MASTER CONTROLLER.

SECTION 861. DIGITAL TIME SWITCH

861.01 Description. This work shall consist of furnishing, installing, and setting a digital time switch, with necessary connections for proper operation.

861.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Digital Time Switch	1074.01

861.03 Basis of Payment. This work will be paid for at the contract unit price per each for DIGITAL TIME SWITCH.

SECTION 862. UNINTERRUPTABLE POWER SUPPLY (UPS)

862.01 Description. This work shall consist of furnishing and installing an uninterruptable power supply (UPS).

862.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Uninterruptable Power Supply	1074.04

CONSTRUCTION REQUIREMENTS

862.03 General. The UPS shall provide power for full run-time operation for an “LED-only” intersection (all colors red, yellow, and green) or flashing mode operation for an intersection using red LED’s. A UPS that provides a minimum of two hours of full run-time operation will be designated as “standard”. A UPS that provides a minimum of six hours of full run-time operation will be designated as “extended”.

The UPS shall include, but not be limited to the following: inverter/charger, power transfer relay, batteries, a separate manually operated non-electronic bypass switch, and all necessary hardware and interconnect wiring according to the plans. The UPS shall provide reliable emergency power to the traffic signals in the event of a power failure or interruption. The transfer from utility power to battery power and visa versa shall not interfere with the normal operation of traffic controller, conflict monitor/malfunction management unit, or any other peripheral devices within the traffic controller assembly.

The UPS shall be designed for outdoor applications, and shall meet the environmental requirements of, “NEMA Standards Publication No. TS 2 – Traffic Controller Assemblies”, except as modified herein.

862.04 Installation. When a UPS is installed at an existing traffic signal cabinet, the UPS cabinet shall partially rest on the lip of the existing controller cabinet foundation and be secured to the existing controller cabinet by means of at least four bolts. The UPS cabinet shall include a bottom constructed of the same material as the cabinet.

When a UPS is installed at a new signal cabinet and foundation, it shall be mounted as shown on the plans.

862.05 Basis of Payment. This work will be paid for at the contract unit price per each for UNINTERRUPTABLE POWER SUPPLY, STANDARD or UNINTERRUPTABLE POWER SUPPLY, EXTENDED.

SECTION 863. CONTROLLER CABINET AND PERIPHERAL EQUIPMENT

863.01 Description. This work shall consist of furnishing and installing a cabinet and peripheral equipment for an existing traffic signal controller.

863.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Controller Cabinet and Peripheral Equipment	1074.03

CONSTRUCTION REQUIREMENTS

863.03 General. The cabinet shall be furnished with panel, terminal facilities, conflict monitor, load switches, and flasher relays complete with necessary connections for proper operation. The type of cabinet shall be as specified on the plans.

863.04 Basis of Payment. This work will be paid for at the contract unit price per each for CONTROLLER CABINET, of the type specified.

SECTION 864. TRANSCEIVER-FIBER OPTIC

864.01 Description. This work shall consist of furnishing and installing a fiber optic transceiver for a traffic signal controller.

CONSTRUCTION REQUIREMENTS

864.02 General. The fiber optic transceiver shall be installed according to Section 859 and the following.

All fiber optic components, except the interconnect cable itself, required to provide proper communication between local controllers and/or masters, shall be furnished and installed as part of this item.

864.03 Transceiver Components. The transceiver and all related components and connections shall be provided for the proper operation of the fiber optic interconnect communication system in each traffic signal cabinet. These items shall include but not be limited to the following.

- (a) Distribution Enclosure. Field cable shall terminate in the controller cabinet within a wall-mount distribution enclosure. The distribution enclosure shall seal out dust and moisture. The size shall be sufficient to store all fiber windings and splices. The location of the distribution enclosure shall not restrict access to other controller components. The field cable shall be firmly secured to the enclosure with hose clamps or similar clamping devices. The cabinet cable shall leave the enclosure through rubber grommets or similar devices to protect the cable against wear. The field cable jacket shall be removed and all protective gel cleaned from the loose tubes as

recommended by the cable supplier. Sufficient lengths of every loose tube shall be coiled within the enclosure to reach the fiber interface panel or modem.

- (b) Connectors. Only ST type connectors of ceramic ferrule and Physical Contact (PC) end finish shall be used to terminate fibers to equipment. ST or mechanical connectors shall not be used to splice cables.
- (c) Splices. The fiber optic cable shall be installed in continuous runs between controller cabinets or as marked on the plans. No splices will be allowed outside the controller cabinets. Only mechanical or fusion splices will be allowed in the controller cabinet. The splices shall be secured in a splice organizer tray.
- (d) Modems and Power Source. Communication between local controllers and the system master controllers shall be facilitated by the use of fiber optic modems. The modems shall be capable of communications with NEMA traffic signal controllers in a coordinated closed loop system. Modems shall be active devices providing full-duplex communication via RS-232 connector and supporting daisy-chain wiring. The nominal operating wavelength shall be 850 nm. The modems shall be according to NEMA Standards for Traffic Control Systems, TS1, Section 2. A minimum of two fiber optic ports shall be provided on each modem. Each fiber optic port shall be ST-PC style and shall be identified as either transmitter or receptor of the optic signal. The other end of the modem shall have the male type RS-232 connector. The modems shall be installed on the interface panel on the side of the controller cabinet. The modems shall be powered from the controller telemetry module.
- (e) Light Source. An LED light source with a wavelength that is the system wavelength shall be used. The LED shall be stable within 0.1 dB in intensity over a time period sufficiently long enough to perform the measurement. The output of the LED shall overfill the input end of the launch fiber in both numerical aperture (NA) and core diameter.
- (f) Power Meter. The detector in the power meter shall have an effective NA and active region that is larger than the receive reference cable and/or the fiber under test. The power meter shall have a minimum range from +3 dBm to -40 dBm. The power meter shall have an accuracy of ± 0.5 dB through the operating temperature and minimum resolution of 0.1 dB.
- (g) Breakout Kits. Breakout kits shall provide for the separation and protection of individual fibers with buffer tubing and jacketing materials suitable for termination of the fiber with the fiber optic connectors as specified.
- (h) Interface Panel. This panel interfaces the controller telemetry to the fiber optic modems and provides terminal block tie points for the other telemetry signals. A terminal for each conductor in the cable shall be required.

864.04 Testing and Product Information. Field testing of the equipment shall be according to Article 801.13(d). All components of the fiber optic system shall have the manufacturer's name, address, type, style, model or serial number, and

catalog number on a plate secured to the equipment. It is advised that the system be from the same manufacture to assure uniformity, interchangeability of components, single responsibility, and most satisfactory service.

864.05 Basis of Payment. This work will be paid for at the contract unit price per each for TRANSCEIVER - FIBER OPTIC, for each traffic signal cabinet.

WIRE AND CABLE

SECTION 870. MULTI-CONDUCTOR POWER CABLE

870.01 Description. This work shall consist of furnishing and installing multi-conductor direct burial power cable, complete with all splicing, identifications, and terminations.

870.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Multi-Conductor Power Cable	1076.01
(b) Splicing and Termination of Electric Cable	1066.06

CONSTRUCTION REQUIREMENTS

870.03 Installation. The multi-conductor cable extended to equipment shall be of a length sufficient for cable splices to be withdrawn a minimum of 18 in. (450 mm) out of pole handholes, pull boxes, or junction boxes.

For preparation of cable termination or splicing, the multi-conductor cable jacket and any underlying tape, shall be removed for a distance of 8 in. (200 mm) from the end of the center conductor. The fillers shall be removed and cut at the end of the jacket. The assembly shall be taped tightly together at the end of the jacket before the conductors are spread apart.

Multi-conductor cable shall not be bent to a radius less than the manufacturer's recommended bending radius, either in permanent placement or during installation.

The cable shall be installed directly from the reels on which the cable was shipped. Dragging or laying cable on the ground will not be permitted. No underground splicing of cable will be permitted.

Immediately after placement, the cable ends shall be sealed to prevent entrance of moisture and contaminants, unless splicing or termination work is performed concurrently.

The multi-conductor cable assembly shall be terminated with a multi-leg heat-shrink boot. The end of the cable shall be wrapped with sealant tape recommended by the boot manufacturer around and between individual insulated conductors, with the boot overall. The boot shall meet military specification SAE-AS81765/1.

- (a) In Trench. The cable shall be installed according to Article 810.04 and according to the manufacturer's recommendations, except plowing will not be allowed.
- (b) In Raceway. Raceways shall be cleaned and freed of rough spots by reaming or other methods approved by the Engineer. All raceways shall be swabbed and blown clean with compressed air. Lubricating compounds approved by the cable manufacturer shall be used to facilitate installation of the cable in raceways.

The manufacturer's recommended allowable tension for the conductor or the allowable sidewall load, whichever is smaller, shall be used for maximum pulling tension. Cable pulling apparatus shall have no sharp edges or protrusions which could damage cables or raceways.

870.04 Method of Measurement. Cable will be measured for payment according to Article 817.04.

870.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for ELECTRIC CABLE ASSEMBLY IN CONDUIT, or TRENCH, 600V of the type, size, and number of conductors specified.

SECTION 871. FIBER OPTIC CABLE

871.01 Description. This work shall consist of furnishing and installing all accessories required and the fiber optic cable of the type, size, and number of fibers specified.

871.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Fiber Optic Cable	1076.02

871.03 Contractor Qualifications. The fiber optic cable installation shall be supervised by trained and experienced personnel. The cable terminations and splices shall be made by qualified technicians. Upon request by the Engineer, the Contractor shall provide documentation on qualifications and experience for fiber optic equipment installations. The Engineer will determine if the Contractor is qualified to perform the work.

CONSTRUCTION REQUIREMENTS

871.04 Cable Installation. The fiber optic cable shall be installed in continuous runs between controller cabinets or as marked on the plans. No splices shall be allowed outside the controller cabinet. The cable end shall be secured inside the controller cabinet so no load is applied to the exposed fiber strands.

Cable Minimum Bend Radius. For static storage, the cable shall not be bent at any location to less than ten times the diameter of the cable outside diameter or as recommended by the manufacturer. During installation, the cable shall not be bent at

any location to less than 15 times the diameter of the cable outside diameter or as recommended by the manufacturer.

Extra Cable. Extra cable shall be left in each handhole and double handhole, at the top of each conduit riser, and at each wood support pole according to the following requirements. Storage of additional extra cable in each handhole shall be coiled. These coils shall be bound at a minimum of three points around the coil perimeter and supported in their static storage positions. Storage of additional cable adjacent to conduit risers and support poles shall be as detailed on the plans. The minimum of extra cable amounts shall be as follows.

Location	Extra Cable Length	
	feet	(meters)
Gulfbox	1.5	0.5
Junction Box	1.5	0.5
Handhole	6.5	2.0
Double Handhole	13.0	4.0
Conduit Riser	13.0	4.0
Support Pole	13.0	4.0

Cable Termination. Field cable shall terminate in the controller cabinet within a wall-mounted distribution enclosure according to Article 864.03.

- (a) **Installation in Conduits and Ducts.** A suitable cable feeder guide shall be used between the cable reel and the face of the conduit/duct to protect the cable and to guide it into the conduit off the reel. The cable shall be carefully inspected for jacket defects. If defects are noticed, the pulling operation shall be stopped immediately and the Engineer shall be notified.

Precautions shall be taken during installation to prevent the cable from being kinked or crushed. A pulling eye shall be attached to the cable and used to pull the cable through the conduit. A pulling swivel shall be used to eliminate twisting of the cable. As the cable is played off the reel into the cable feeder guide, it shall be lubricated with a type of lubricant recommended by the cable manufacturer. The lubricant used shall be a water based type and approved by the cable manufacturer. Dynamometers or break away pulling swing shall be used to ensure that the pulling line tension does not exceed the installation tension specified by the cable manufacturer. Maximum length of cable pulling tensions shall not exceed the cable manufacturer's recommendations. The mechanical stress placed on a cable during installation shall not be such that the cable is twisted or stretched. The pulling of the cable shall be hand assisted at each controller cabinet. The cable shall not be crushed, kinked, or forced around a sharp corner. A sufficient length of cable shall be left at each end of the cable to allow proper cable termination. At the controller cabinet and at the handhole the cable shall be visibly marked/tagged as "CAUTION-FIBER OPTIC CABLE".

- (b) **Installation on Aerial Spans.** The fiber cable shall be lashed onto the aerial support span wire. The aerial support shall be existing span wire, or new span wire according to Section 872. When the existing interconnect is

supported by messenger cable and hanger rings, the rings and interconnect cable shall be removed. Existing conduit risers designated for reuse with the fiber optic interconnect shall have the existing weatherhead removed. Removal of these items shall be included in the cost of the fiber optic cable. The fiber optic cable shall be secured to the support cable by lashing with a cable lasher. The lashing wire shall be a dielectric lashing filament to prevent the conductance or attraction of lightning. The lashing wire shall be securely tied off when terminated near each support pole.

- (c) Cable Placement into Conduit Risers. Kellum grips and/or other hanger devices shall be used to support the vertical drop of the cable and to prevent any possible kinking of the cable after installation. The top of the risers shall have a hexnut type watertight service entrance connector with an oval shaped grommet. The grommet shall be either neoprene or rubber. The voids between the fiber optic cable(s) and the grommet shall be sealed with silicone.

The fiber optic cable shall be tested according to Article 801.13(d).

871.05 Method of Measurement. Cable will be measured for payment in feet (meters) in place. Cable will be measured horizontally and vertically between the changes in direction, including the cable in the vertical conduit riser and any extra cable as specified in Article 871.04. The cable length in the foundations of a controller cabinet and a vertical pole will be accounted as 3 ft (1 m) each.

871.06 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for FIBER OPTIC CABLE of the method of installation (in conduit or on messenger), of the type, size, and number of fibers specified.

The cable warning tags will be included in the cost of the fiber optic cable.

SECTION 872. SPAN WIRE AND TETHER WIRE

872.01 Description. This work shall consist of furnishing and installing span wire or tether wire and accessories.

872.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Span Wire and Tether Wire	1076.03

CONSTRUCTION REQUIREMENTS

872.03 Installation. The span wire or tether wire with accessories shall be installed according to the details shown on the plans.

872.04 Method of Measurement. Span wire and tether wire will be measured for payment in feet (meters) in place. Measurements will be along the horizontal distances between the supporting poles.

872.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for SPAN WIRE or TETHER WIRE.

Any additional span wire or tether wire required for sag and wrap around shall be included in the cost of the wire specified.

SECTION 873. ELECTRIC CABLE

873.01 Description. This work shall consist of furnishing and installing an electric cable of the type, size, and number of conductors specified.

873.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Electric Cable – Signal, Lead-in, Communication, Service, and Equipment Grounding Conductor	1076.04
(b) Electrical Raceway Materials	1088.01

CONSTRUCTION REQUIREMENTS

873.03 Installation. The electric cable may be installed in a trench, in a conduit, or aerially suspended, as indicated on the plans. When installed in a trench, the electric cable shall have a minimum depth of 2.5 or 2 ft (750 or 600 mm) as indicated on the plans.

The color coded conductor shall be connected according to the following schedule.

- (a) Signal Cable - Signal Head (5 Conductor or 7 Conductor)

Conductor No.	Base Color	Tracer Color	Connection
1	Black		AC, Neutral
2	White		Red Circle Indication (AC,Line)
3	Red		Green Circle Indication (AC,Line)
4	Green		Yellow Circle Indication (AC,Line)
5	Orange		Yellow Arrow Indication (AC,Line)
6	Blue		Green Arrow Indication (AC,Line)
7	White	Black	

- (b) Signal Cable - Pedestrian Signal Head

Conductor No.	Base Color	Tracer Color	Connection
1	Black		AC, Neutral
2	White		Don't Walk (AC,Line)
3	Red		Walk (AC,Line)
4	Green		

(c) Signal Cable - Pedestrian Push-Button

Conductor No.	Base Color	Tracer Color	Connection
1	Black		24 V DC
2	White		Cabinet Logic Ground

(d) Lead-in Cable (Single-Pair)

Conductor No.	Color	Connection
1	Black	Loop Detector - Loop Signal
2	Non-Black	Loop Detector - Loop Neutral

(e) Communication Cable or Lead-in Cable (Multipair)

Conductor No. (Each Pair)	Color	Connection
1	Black	Signal
2	Non-Black	Neutral/Logic Ground

(f) Service Cable

Conductor No.	Color	Connection
1	Black	AC, Line
2	White	AC, Neutral

The length of extra cable shall be provided according to the following schedule.

Location	Length of Cable	
	feet	(meters)
Gulfbox	1.5	0.5
Junction Box	1.5	0.5
Handhole	6.5	2.0
Double Handhole	13.0	4.0

Cable splices shall be made only at connections to detector loops or at the locations specified on the plans. When making a cable splice, the following procedures shall be used.

- (1) Remove all outer cable coverings, leaving 4 in. (100 mm) of insulated wire exposed.
- (2) Remove insulation for 1 in. (25 mm) and scrape copper conductors.
- (3) Connect conductors by twisting and soldering together.
- (4) Wrap each conductor separately with rubber or vinyl electrical tape. The wrapping shall completely cover the twisted connection and the insulation

1 in. (25 mm) beyond all exposed copper wire on either end of the connection.

- (5) Scrape the cable sheath clean and place the cable in a rigid mold or a container. The mold or container shall be of a type acceptable to the Engineer.
- (6) Center all conductors in molds or containers.
- (7) Fill the mold or container with epoxy resin or polyurethane compound. The epoxy resin or polyurethane compound used shall be dielectric, waterproof, and approved by the Engineer.

All stranded conductors shall be terminated in the cabinet using crimp-on connectors.

Electric cables shall be pulled into conduit by training the cables at the entrance to the conduit to prevent twisting or overlapping. Detector lead-in cables shall be placed on top of signal cables. When three or more cables are pulled into a conduit, a fast-drying, water based lubricant recommended by the cable manufacturer shall be applied on the cables.

873.04 Grounding System. All traffic signal circuits shall include an equipment grounding conductor according to Article 801.04. The equipment grounding conductor shall consist of a continuous, green, insulated conductor Type XLP, No. 6 AWG, stranded copper installed in raceways and bonded to each metal enclosure (handhole, post, mast arm pole, signal cabinet, etc.). All clamps shall be bronze or copper, and UL listed as ground connectors.

A grounding cable with connectors shall be installed between each handhole cover and frame. The grounding cable shall be looped over cable hooks installed in the handholes and 5 ft (1.5 m) of extra cable shall be provided between the frame and cover.

All equipment grounding conductors shall terminate at the ground bus in the controller cabinet. The neutral conductor and the equipment grounding conductor shall be connected in the service installation. At no other point in the traffic signal system shall the neutral and equipment grounding conductors be connected.

873.05 Method of Measurement. Electric cable will be measured for payment in feet (meters) in place. The length of measurement shall be the distance horizontally and vertically measured between the changes in direction, including cables in mast arms, mast arm poles, signal posts, and extra cable length as specified in Article 873.03. The vertical cable length shall be measured according to the following schedule.

Location	Cable Length
Foundation (signal post, mast arm pole, controller cabinet)	3 ft (1 m)
Mast Arm Pole (mast arm mounted signal head)	20 ft (6 m)
Mast Arm Pole (bracket mounted signal head attached to mast arm pole)	13 ft (4 m)
Signal Post (bracket or post mounted signal head)	13 ft (4 m)
Pedestrian Push Button	6 ft (2 m)

873.06 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for ELECTRIC CABLE, of the method of installation (IN TRENCH, IN CONDUIT, or AERIAL SUSPENDED), of the type, size, and number of conductors or pairs specified.

The type specified will indicate the method of installation and whether the electric cable is Service, Signal, Lead-in, Communication, or Equipment Grounding Conductor.

POSTS AND FOUNDATIONS

SECTION 875. TRAFFIC SIGNAL POST

875.01 Description. This work shall consist of furnishing and installing a metal traffic signal post.

875.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Traffic Signal Post	1077.01

CONSTRUCTION REQUIREMENTS

875.03 Installation. The traffic signal post shall be erected plumb, securely bolted to a concrete foundation, and grounded to a ground rod according to the details shown on the plans. No more than 3/4 in. (20 mm) of the post threads shall protrude above the base. The vertical clearance between the bottom of a bracket or post mounted signal head or pedestrian signal head and the crown of the pavement shall be between 8 and 15 ft (2.5 and 4.5 m).

When the signal head is not mounted on the top of the post, a pipe cap shall be furnished and installed on the top of the post. The Contractor shall apply an anti-seize paste compound on all nuts and bolts prior to assembly.

Prior to the assembly, the Contractor shall apply two additional coats of galvanized paint on the threads of the post and the base. The Contractor shall use a fabric post tightner to screw the post to the base.

875.04 Basis of Payment. This work will be paid for at the contract unit price per each for TRAFFIC SIGNAL POST, of the type and length specified.

When a particular kind of material is specified for the post and base assembly, the work will be paid for at the contract unit price per each for TRAFFIC SIGNAL POST, PAINTED STEEL; TRAFFIC SIGNAL POST, GALVANIZED STEEL; or TRAFFIC SIGNAL POST, ALUMINUM.

SECTION 876. PEDESTRIAN PUSH-BUTTON POST

876.01 Description. This work shall consist of constructing a concrete foundation, and furnishing and installing a pedestrian push-button post.

876.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Pedestrian Push-Button Post	1077.02
(b) Traffic Signal Post.....	1077.01
(c) Portland Cement Concrete (Note 1)	1020

Note 1. Class SI concrete shall be used.

CONSTRUCTION REQUIREMENTS

876.03 Installation. The pedestrian push-button post shall be installed plumb on a concrete foundation according to the details shown on the plans. The Contractor shall apply an anti-seize paste compound on all nuts and bolts prior to assembly.

876.04 Basis of Payment. This work will be paid for at the contract unit price per each for PEDESTRIAN PUSH-BUTTON POST, TYPE I or PEDESTRIAN PUSH-BUTTON POST, TYPE II.

When a galvanized post is specified, the work will be paid for at the contract unit price per each for PEDESTRIAN PUSH-BUTTON POST, GALVANIZED STEEL, TYPE I or PEDESTRIAN PUSH-BUTTON POST, GALVANIZED STEEL, TYPE II.

SECTION 877. MAST ARM ASSEMBLY AND POLE

877.01 Description. This work shall consist of furnishing and installing a steel mast arm assembly and pole.

877.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Mast Arm Assembly and Pole	1077.03

CONSTRUCTION REQUIREMENTS

877.03 Installation. The components of a mast arm assembly and pole shall be assembled and erected according to the details shown on the plans. The pole shall be erected vertically on a concrete foundation. The Contractor shall furnish and install the required nuts and washers for mounting and plumbing the pole on the anchor rods. After the entire assembly has been aligned and plumbed, a stainless steel mesh 1/4 in. (6 mm) maximum opening with a minimum wire diameter AWG No. 16 (1.5 mm) shall be stainless steel banded to the anchor rods with a minimum 2 in. (50 mm) lap to enclose the void between the mast arm base plate and the concrete foundation. The pole shall be grounded according to Section 806.

The Contractor shall take precautions to avoid scratching the galvanized coating on the mast arm pole and assembly during the transportation and erection. If it is scratched, the Contractor shall repair the galvanized coating according to ASTM A 780 and the manufacturer's recommendations. The Contractor shall apply an anti-seize paste compound on all nuts and bolts prior to assembly.

A combination mast arm assembly and pole shall not be installed without the luminaire.

877.04 Basis of Payment. This work will be paid for at the contract unit price per each for STEEL MAST ARM ASSEMBLY AND POLE or STEEL COMBINATION MAST ARM ASSEMBLY AND POLE, of the signal arm length specified.

SECTION 878. TRAFFIC SIGNAL CONCRETE FOUNDATION

878.01 Description. This work shall consist of constructing a concrete foundation for a traffic signal post, controller base, or mast arm pole.

878.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Reinforcement Bars	1006.10(a)
(c) Anchor Rods	1006.09

CONSTRUCTION REQUIREMENTS

878.03 Installation. Construction requirements for reinforcement shall be according to Section 508. The top of the foundation shall be finished level. Shimming of the appurtenance to be attached will not be permitted. A form extending a minimum of 9 in. (225 mm) and a maximum of 24 in. (600 mm) below the top surface of the foundation is required. The form shall be set level, and means shall be provided for holding it rigidly in place while the concrete is being deposited. The form shall remain undisturbed for at least 24 hours after the concrete has been poured.

Where a concrete foundation is contiguous to a sidewalk, preformed joint filler of 1/2 in. (13 mm) thickness shall be placed between the foundation and the sidewalk.

All raceways in the foundation shall be installed rigidly in place before concrete is deposited in the form. Bushings shall be provided at the ends of conduit. Anchor rods and ground rod shall be set in place before the concrete is deposited by means of a template constructed to space the anchor rods according to the pattern of the bolt holes in the base of the appurtenance to be attached.

Grounding electrodes shall be according to Section 806.

- (a) Square or Rectangular Foundations. Whenever the excavation is irregular, a form shall be used to provide the proper dimension of the entire foundation below the ground surface.
- (b) Drilled Shaft Foundations. Drilled shaft foundations shall be constructed according to Section 516 and the following.

The submittal requirements as stated in Article 516.04 shall not apply and the entire length of the drilled shaft shall be vibrated.

Concrete shall be cured before poles are installed.

878.04 Method of Measurement. The foundation will be measured for payment in feet (meters) in place. The length measured will be limited to that shown on the plans or authorized by the Engineer.

Excavation in rock will be measured for payment according to Article 502.12.

878.05 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) of depth of CONCRETE FOUNDATION, of the type specified.

Excavation in rock will be paid for according to Article 502.13.

Obstruction mitigation will be paid for according to Article 109.04.

SECTION 879. DRILL EXISTING FOUNDATION OR HANDHOLE

879.01 Description. This work shall consist of drilling a hole in an existing concrete foundation or handhole and for furnishing and installing a new conduit.

CONSTRUCTION REQUIREMENTS

879.02 General. The size of the hole shall be as close as possible to the size of the conduit. A conduit of the size required shall be installed in the drilled hole. A bushing shall be provided at the end of the conduit. The space between the conduit and the foundation shall be sealed with a waterproof caulk.

879.03 Basis of Payment. This work will be paid for at the contract unit price per each for DRILL EXISTING FOUNDATION or DRILL EXISTING HANDHOLE, which price shall include all necessary excavation and backfilling outside of the foundation or handhole.

SIGNAL HEADS

SECTION 880. LIGHT EMITTING DIODE (LED) SIGNAL HEAD AND OPTICALLY PROGRAMMED LED SIGNAL HEAD

880.01 Description. This work shall consist of furnishing and installing a light emitting diode (LED) signal head or an optically programmed LED signal head.

880.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Light Emitting Diode (LED) Signal Head and Optically Programmed LED Signal Head.....	1078.01

CONSTRUCTION REQUIREMENTS

880.03 Installation. The signal head shall be installed on a post, bracket, span wire, or mast arm as shown on the plans. Other methods of attaching the signal head to a post, a mast arm pole, or a mast arm may be used upon approval by the Engineer. Signal heads consisting of only one face and up to three sections may be post mounted.

Each signal face shall be pointed in the direction of the approaching traffic it is to control and be aimed to have maximum effectiveness for an approaching driver located at a distance from the stop line equal to the normal distance traversed while stopping. The optically programmed signal face shall be veiled according to the visibility requirements at the direction of the Engineer.

The size of each signal lens shall be 12 in. (300 mm).

During construction and until the installation is placed in operation, all signal faces, including any traffic signal backplate, shall be completely covered with an opaque material. The covering material shall be securely fastened so it will not be disturbed by normal inclement weather or wind. The color of the covering materials shall be other than black and shall differentiate the signal as being covered.

880.04 Basis of Payment. This work will be paid for at the contract unit price for SIGNAL HEAD, LED or OPTICALLY PROGRAMMED SIGNAL HEAD, LED of the type specified, and of the particular kind of material, when specified.

If a signal head with both standard and optically programmed signal faces is required, it will be paid for as a COMBINATION SIGNAL HEAD, LED.

The type specified will indicate the number of signal faces, the number of signal sections in each signal face, and the method of mounting.

SECTION 881. LIGHT EMITTING DIODE (LED) PEDESTRIAN SIGNAL HEAD

881.01 Description. This work shall consist of furnishing and installing a light emitting diode (LED) pedestrian signal head or an LED countdown pedestrian signal head.

881.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Light Emitting Diode (LED) Pedestrian Signal Head	1078.02

CONSTRUCTION REQUIREMENTS

881.03 Installation. The pedestrian signal head shall be installed on a post or bracket as shown on the plans. Other methods of attaching the pedestrian signal head to a post or a mast arm pole may be used upon approval by the Engineer.

Each pedestrian signal face shall be aimed to provide maximum visibility at the beginning of the controlled crossing.

All pedestrian signal faces at an intersection shall be of the same type and same display.

During construction and until the installation is placed in operation, all pedestrian signal faces shall be completely covered with an opaque material. The covering material shall be securely fastened so it will not be disturbed by normal inclement weather or wind. The color of the covering material shall be other than black and shall differentiate the pedestrian signal faces as being covered.

881.04 Basis of Payment. This work will be paid for at the contract unit price per each for PEDESTRIAN SIGNAL HEAD, LED or PEDESTRIAN SIGNAL HEAD, LED COUNTDOWN, of the particular kind of material, when specified, and of the type specified.

The type specified will indicate the number of faces and the method of mounting.

SECTION 882. TRAFFIC SIGNAL BACKPLATE

882.01 Description. This work shall consist of furnishing a traffic signal backplate and attaching it to a traffic signal face.

882.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Traffic Signal Backplate	1078.03

CONSTRUCTION REQUIREMENTS

882.03 Installation. The traffic signal backplate shall be securely attached to a traffic signal face with noncorrosive bolts, locknuts, and washers. At least one bolt shall be used on each side of a signal section in contact with the backplate.

882.04 Basis of Payment. This work will be paid for at the contract unit price per each for TRAFFIC SIGNAL BACKPLATE, of the type specified, and of the particular kind of material, when specified.

SECTION 883. DIRECTIONAL LOUVER

883.01 Description. This work shall consist of furnishing and installing a directional louver for a 12 in. (300 mm) signal lens in the signal heads.

883.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Directional Louver	1078.04

CONSTRUCTION REQUIREMENTS

883.03 Installation. The directional louver shall provide an angle of cutoff on each side of the center axis of the light beam as follows.

Type A	0 to 6 degrees
Type B	7 to 10 degrees
Type C	11 to 14 degrees

The directional louver shall be installed inside the signal visor in front of the signal lens and secured in place with a minimum of two metal screws.

883.04 Basis of Payment. This work will be paid for at the contract unit price per each for DIRECTIONAL LOUVER, of the type specified.

When used with a 8 in. (200 mm) lens, this work will be paid for at the contract unit price per each for DIRECTIONAL LOUVER, of the type specified.

DETECTION

SECTION 885. INDUCTIVE LOOP DETECTOR

885.01 Description. This work shall consist of furnishing and installing an inductive loop detector.

885.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Inductive Loop Detector	1079.01

CONSTRUCTION REQUIREMENTS

885.03 Installation. The inductive loop detector shall be installed inside a traffic signal controller cabinet. The detector shall be either card rack type or shelf-mounted type. The detector may be single-channel, two-channel, or four-channel.

885.04 Basis of Payment. This work will be paid for at the contract unit price per each for INDUCTIVE LOOP DETECTOR or INDUCTIVE LOOP DETECTOR WITH SYSTEM OUTPUT, which price shall include the necessary connections and adjustments for proper operation.

If the detector unit has more than one complete detection channel, each complete detection channel will be considered as a detector for payment.

SECTION 886. DETECTOR LOOP

886.01 Description. This work shall consist of furnishing and installing a detector loop in the pavement.

886.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Detector Loop and Sealer	1079.02

The detector loop and sealer shall be according to the recommendations of the manufacturer of the related inductive loop detector as needed for proper operation.

CONSTRUCTION REQUIREMENTS

886.03 Testing. The detector loop shall be tested according to Article 801.13(b)(2).

886.04 Installation. The detector loop location, shape, size, and the number of turns shall be as shown on the plans or as recommended by the manufacturer of the related inductive loop detector. Multiple loops connected to the same detector channel shall be connected in series or as directed by the Engineer. The detector loop shall be installed in the pavement according to the details shown on the plans and the following requirements.

- (a) Type I detector loop shall consist of furnishing a detector loop wire enclosed in a flexible tubing and installing it in a sawed slot in the pavement.

The sawed slot shall be clean, dry, and have a smooth bottom. Diagonal saw cuts or drilled holes shall be made at all corners to prevent sharp bends in the wire. The saw cuts at the corners shall be overlapped so they have full depth. The slot shall be cleaned by air pressure removing any debris and water, if any present. Each tube containing the loop wire shall be pushed into the saw cut with a wooden stick and not with any metal tool.

Retainers shall be added to the sawed slot to prevent the loop wires from floating during the pouring of the loop sealant. These retainers shall be 1 in. (25 mm) pieces of the tubing bent in half. The loop wires not embedded in the pavement shall be evenly twisted approximately 5 turns per foot (16 turns per meter).

- (b) Type II detector loop shall consist of furnishing a mineral-insulated metal-sheathed cable, installing it on a HMA or portland cement concrete base course and covering it with a HMA surface course. The surface course shall be between 2 and 5 in. (50 and 125 mm) thick. The cable shall be secured to the base course by a method approved by the Engineer. Slanted holes shall be drilled through the base course. The leads shall be bound together with tie wraps or fish tape rope, inserted through the hole, and positioned in place to make splices in the junction box or handhole.

The end of the cable shall be stripped, insulated and installed in a sleeve assembly according to the manufacturer's instructions to prevent moisture from entering the cable. The sleeved conductors shall be spliced together to form one continuous length. As each splice is made, it shall be metered to ensure a proper connection. The conductors must be soldered together and each conductor completely wrapped with two layers of rubber or vinyl electrical tape.

- (c) Type III detector loop shall consist of one of the following.

- (1) Rigid Plastic Conduit. This detector loop shall consist of furnishing a detector loop wire sealed with asphalt rubber or waterproof flexible sealant inside a rigid plastic conduit, installing it on a HMA or portland cement concrete base course and covering it with a HMA surface course. The surface course shall be between 2 and 5 in. (50 and 125 mm) thick. The conduit shall be secured to the base course by a method approved by the Engineer. Slanted holes shall be drilled through the base course. The plastic conduit shall be inserted through the hole toward the junction box or handhole.
- (2) Heavy Duty Reinforced Rubber Conduit. This detector loop shall consist of furnishing a detector wire sealed with asphalt rubber or waterproof flexible sealant inside a conduit made of heavy duty reinforced rubber hose.

When the detector loop is installed on a HMA or portland cement concrete base course, and covered by a HMA surface course, the surface course shall be between 2 and 5 in. (50 and 125 mm) thick.

When the detector loop is covered by portland cement concrete surface course, the surface course shall be between 2 and 16 in. (50 and 400 mm) thick. The conduit shall be secured to the base course by a method approved by the Engineer. The conduit shall be secured to reinforcing steel in the pavement, at each point the conduit crosses the reinforcing steel, in order to prevent shifting of the loop as the surface course is poured. When loops are secured to the top of reinforcing steel, care must be taken to prevent the steel from cutting into the conduit when the portland cement concrete surface course is poured over the top. In new roadways, the conduit may be placed directly on top of the gravel substrate.

886.05 Method of Measurement. This work will be measured for payment in feet (meters) in place. Type I detector loop will be measured along the sawed slot in the pavement containing the loop and lead-in, rather than the actual length of the wire. Type II and Type III detector loops will be measured along the detector loop and lead-in embedded in the pavement, rather than the actual length of the wire.

886.06 Basis of Payment. This work will be paid for at the contract unit price per foot (meter) for DETECTOR LOOP, of the type specified.

SECTION 887. EMERGENCY VEHICLE PRIORITY SYSTEM

887.01 Description. This work shall consist of furnishing a light transmitter, furnishing and installing a light detector, or a light detector amplifier, for an emergency vehicle priority system.

887.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Emergency Vehicle Priority System	1072

CONSTRUCTION REQUIREMENTS

887.03 Installation. The light transmitter shall be furnished to the user as directed by the Engineer.

The light detector shall be installed on or near a traffic signal head with necessary connections for proper operation, as indicated on the plans. The confirmation beacon shall be installed near the light detector or as indicated on the plans and shall face in the same direction as the corresponding light detector.

The light detector amplifier shall be installed inside a traffic signal controller cabinet or in the light detector housing.

887.04 Basis of Payment. This work will be paid for at the contract unit price per each for LIGHT TRANSMITTER, LIGHT DETECTOR, or LIGHT DETECTOR AMPLIFIER.

Art. 887.04

Emergency Vehicle Priority System

Furnishing and installing a confirmation beacon shall be included in the cost of the light detector.

SECTION 888. PEDESTRIAN PUSH-BUTTON

888.01 Description. This work shall consist of furnishing and installing a pedestrian push-button and an appropriate traffic signal instruction sign.

888.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Pedestrian Push-Button	1074.02

CONSTRUCTION REQUIREMENTS

888.03 Installation. The pedestrian push-button shall be mounted not less than 36 in. (900 mm) and not more than 42 in. (1050 mm) above the sidewalk level. The mounting station shall be completely in contact with the post or pole on which it is mounted according to the plans and shall be fully accessible from a paved or concrete surface. The Contractor shall apply an anti-seize paste compound on all nuts and bolts prior to assembly. The methods of mounting both the pedestrian push-button and the sign shall be approved by the Engineer.

888.04 Basis of Payment. This work will be paid for at the contract unit price per each for PEDESTRIAN PUSH-BUTTON.

MISCELLANEOUS

SECTION 890. TEMPORARY TRAFFIC SIGNAL

890.01 Description. This work shall consist of furnishing, installing, maintaining, and removing a temporary traffic signal installation as shown on the plans.

CONSTRUCTION REQUIREMENTS

890.02 Installation. The Contractor shall notify the Engineer at least 48 hours in advance when the temporary signal installation is ready to be activated. The Engineer will then inspect the installation. After approval by the Department, the maintenance of the temporary signal installation, including all energy charges, shall become the responsibility of the Contractor until removal is directed by the Engineer.

After the removal of the temporary installation, the equipment and materials furnished by the Contractor shall remain the property of the Contractor.

890.03 Maintenance. The temporary traffic signal maintenance shall be according to Article 801.11(b).

890.04 Basis of Payment. This work will be paid for at the contract unit price per each for TEMPORARY TRAFFIC SIGNAL INSTALLATION. Each intersection will be paid for separately.

Following approval of each installation, 60 percent of the bid price will be paid. The remaining 40 percent will be paid following removal of each installation.

SECTION 891. ILLUMINATED SIGN

891.01 Description. This work shall consist of furnishing and installing an illuminated sign.

891.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Illuminated Sign	1084.01

891.03 Basis of Payment. This work will be paid for at the contract unit price per each for ILLUMINATED SIGN, FIBER-OPTIC or ILLUMINATED SIGN, LED.

REMOVAL AND RELOCATION

SECTION 895. REMOVAL, RELOCATION, AND REBUILDING OF EXISTING SIGNAL AND APPURTENANCES

895.01 Description. This work shall consist of the removal, removal and relocation, and/or the rebuilding of existing signal items and appurtenances in the construction of signalized intersections.

CONSTRUCTION REQUIREMENTS

895.02 Relocation. All existing signal items shall be removed and relocated as shown on the plans. The installation shall be done according to the specifications for the specific item. Any damage done to the existing signal items or appurtenances shall be repaired or replaced by the Contractor at his/her own expense, as directed by the Engineer.

Relocation of the existing traffic signal controller and its associated equipment shall also consist of reusing the controller cabinet. Anchor rods, nuts, and washers shall be new for the installation of an existing traffic controller. The controller shall be installed according to Article 857.03.

Relocation of an existing signal head shall consist of removing an existing signal head, optically programmed signal head, light emitting diode (LED) signal head, or combination signal head and installing it according to Article 880.03.

Installation of the pedestrian signal head shall be according to Article 881.03.

Installation of an existing illuminated sign shall be according to Section 891.

Relocation of an existing signal post, controller cabinet, or mast arm assembly and pole shall include the removal and installation on a new concrete foundation with new anchor rods, nuts, and washers, according to Article 878.03.

When removing an existing pedestrian push-button, the related sign shall be removed and installed at the new location. The push-button shall be installed according to Article 876.03.

895.03 Rebuilding Signal Head. The existing signal components shall be removed and altered by adding or removing signal faces and/or mounting hardware. The additional signal faces and/or sections shall be of the same type and make as the existing signals. All lenses and reflectors shall be cleaned, and the reassembled signal head shall be cleaned and repainted. Rebuilding an existing signal head may require removing old components and/or adding new components. All components removed from the existing signal head and not reused shall be disposed of as directed by the Engineer. The Contractor may, without additional compensation, furnish all new components, in lieu of rebuilding. Installation shall be according to Article 880.03.

895.04 Modifying Existing Controller. This work shall consist of modifying an existing controller to change the existing sequence of operation to the proposed sequence of operation. Both the existing and the proposed sequence of operation will be shown on the plans. Upon completion, the Contractor shall furnish the Engineer five copies of the cabinet wiring diagram.

895.05 Removal. Removal of existing signal and appurtenances shall be as follows.

- (a) Existing Traffic Signal Equipment. The existing traffic signal equipment at an intersection shall be removed and disposed of as listed on the plans and as directed by the Engineer. The Contractor shall be responsible for repairing or replacing any items of equipment damaged during the process to the satisfaction of the Engineer.

All equipment shall be stored off the job site at an approved location, and electrical components shall be stored indoors.

- (b) Handhole. The frame and cover of an existing handhole shall be broken off the top section of the handhole wall to a minimum depth of 3 ft (900 mm) below the surrounding grade, or as specified, backfilled with approved material, and the surface reconstructed to match the adjoining area. The concrete debris shall be disposed of outside the right-of-way, and the frame and cover disposed of as directed by the Engineer. If the handhole is located in the sidewalk area, the entire sidewalk square or squares where the handhole is located shall be replaced with new sidewalk.
- (c) Concrete Foundation. The concrete foundation shall be removed to a level at least 3 ft (900 mm) below the adjacent grade, backfilled with approved material, and the surface reconstructed to match the adjoining area. The

foundation shall be disposed of outside the right-of-way. If the concrete foundation is located in the sidewalk area, the entire sidewalk square or squares where the concrete foundation is located shall be replaced with new sidewalk.

- (d) Electric Cable from Conduit. An existing electric cable shall be removed, as directed by the Engineer, from a conduit.

895.06 Removal and Reinstallation. This work shall consist of removing an existing electric cable from a conduit and then reinstalling it in an existing or a new conduit. The conduit shall be cleaned and swabbed prior to reinstallation of cable.

895.07 Method of Measurement. Removal, and removal and reinstallation of existing electric cable will be measured for payment in place in feet (meters). If two or more cables in a conduit are to be removed, or removed and reinstalled, each cable will be measured for payment separately.

Concrete foundations, when specified, will be measured for payment according to Article 878.04.

895.08 Basis of Payment. Removal and Relocation will be paid for at the contract unit price per each for RELOCATE EXISTING SIGNAL HEAD, RELOCATE EXISTING PEDESTRIAN SIGNAL HEAD, RELOCATE EXISTING ILLUMINATED SIGN, or RELOCATE EXISTING PEDESTRIAN PUSH-BUTTON.

Removal and reinstallation of existing traffic signal items will be paid for at the contract unit price per each for RELOCATE EXISTING TRAFFIC SIGNAL CONTROLLER, RELOCATE EXISTING TRAFFIC SIGNAL POST, or RELOCATE EXISTING MAST ARM ASSEMBLY AND POLE.

Concrete foundations, when specified, will be paid for according to Article 878.05.

Rebuilding an existing signal head will be paid for at the contract unit price per each for REBUILD EXISTING SIGNAL HEAD.

Modifying an existing controller will be paid for at the contract unit price per each for MODIFY EXISTING CONTROLLER. Some of the parts and equipment required for the completion of this work may be listed on the plans as separate pay items.

Removal of an existing electric cable will be paid for at the contract unit price per foot (meter) for REMOVE ELECTRIC CABLE FROM CONDUIT.

Removing and reinstalling the electric cable will be paid for at the contract unit price per foot (meter) for REMOVE AND REINSTALL ELECTRIC CABLE FROM CONDUIT.

Removal of existing traffic signal equipment will be paid for at the contract unit price per each for REMOVE EXISTING TRAFFIC SIGNAL EQUIPMENT. Removal of existing handholes will be paid for at the contract unit price per each for REMOVE EXISTING HANDHOLE. Removal of existing concrete foundations will be paid for at the contract unit price per each for REMOVE EXISTING CONCRETE FOUNDATION.

DIVISION 1000. MATERIALS**SECTION 1001. CEMENT**

1001.01 Cement Types. Cement shall be according to the following.

- (a) Portland Cement. Acceptance of portland cement shall be according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Portland or Blended Cement Acceptance Procedure for Qualified and Non-Qualified Plants".

Portland cement shall be according to AASHTO M 85, and shall meet the standard physical and chemical requirements. The Contractor has the option to use any type of portland cement listed in AASHTO M 85 unless a specific cement is specified for a construction item. Inorganic processing additions shall be limited to granulated blast-furnace slag according to the chemical requirements of AASHTO M 302, Class C or F fly ash according to the chemical requirements of AASHTO M 295, and cement kiln dust.

- (b) Portland-Pozzolan Cement. Acceptance of portland-pozzolan cement shall be according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Portland or Blended Cement Acceptance Procedure for Qualified and Non-Qualified Plants".

Portland-pozzolan cement shall be according to AASHTO M 240 and shall meet the standard physical and chemical requirements. The Contractor has the option to use portland-pozzolan cement unless a specific cement is specified for a construction item. Inorganic processing additions shall be limited to granulated blast-furnace slag according to the chemical requirements of AASHTO M 302, Class C or F fly ash according to the chemical requirements of AASHTO M 295, and cement kiln dust. The pozzolan constituent for Type IP using Class F fly ash shall be a maximum of 25 percent of the weight (mass) of the portland-pozzolan cement. The pozzolan constituent for Type IP using Class C fly ash shall be a maximum of 30 percent of the weight (mass) of the portland-pozzolan cement. The pozzolan constituent for Type IP using microsilica or high-reactivity metakaolin shall be a maximum of ten percent. The pozzolan constituent for Type IP using other materials shall have the approval of the Engineer.

Portland-pozzolan cement may be used in concrete mixtures when the air temperature is below 40 °F (4 °C), but the Engineer may request a trial batch of the concrete mixture to show the mix design strength requirement will be met.

- (c) Portland Blast-Furnace Slag Cement. Acceptance of portland blast-furnace slag cement shall be according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Portland or Blended Cement Acceptance Procedure for Qualified and Non-Qualified Plants".

Portland blast-furnace slag cement shall be according to AASHTO M 240 and shall meet the standard physical and chemical requirements. The

Contractor has the option to use portland blast-furnace slag cement unless a specific cement is specified for a construction item. Inorganic processing additions shall be limited to granulated blast-furnace slag according to the chemical requirements of AASHTO M 302, Class C or F fly ash according to the chemical requirements of AASHTO M 295, and cement kiln dust. The blast-furnace slag constituent for Type IS shall be a maximum of 35 percent of the weight (mass) of the portland blast-furnace slag cement.

Portland blast-furnace slag cement may be used in concrete mixtures when the air temperature is below 40 °F (4 °C), but the Engineer may request a trial batch of the concrete mixture to show the mix design strength requirement will be met.

- (d) **Rapid Hardening Cement.** Rapid hardening cement shall be used according to Article 1020.04 or when approved by the Engineer. The cement shall be on the Department's current "Approved List of Packaged, Dry, Rapid Hardening Cementitious Materials for Concrete Repairs", and shall be according to the following.
 - (1) The cement shall have a maximum final set of 25 minutes, according to Illinois Modified AASHTO T 131.
 - (2) The cement shall have a minimum compressive strength of 2000 psi (13,800 kPa) at 3.0 hours, 3200 psi (22,100 kPa) at 6.0 hours, and 4000 psi (27,600 kPa) at 24.0 hours, according to Illinois Modified AASHTO T 106.
 - (3) The cement shall have a maximum drying shrinkage of 0.050 percent at seven days, according to Illinois Modified ASTM C 596.
 - (4) The cement shall have a maximum expansion of 0.020 percent at 14 days, according to Illinois Modified ASTM C 1038.
 - (5) The cement shall have a minimum 80 percent relative dynamic modulus of elasticity; and shall not have a weight (mass) gain in excess of 0.15 percent or a weight (mass) loss in excess of 1.0 percent, after 100 cycles, according to Illinois Modified AASHTO T 161, Procedure B.
- (e) **Calcium Aluminate Cement.** Calcium aluminate cement shall be used according to Article 1020.04 or when approved by the Engineer. The cement shall meet the standard physical requirements for Type I cement according to AASHTO M 85, except the time of setting shall not apply. The chemical requirements shall be determined according to AASHTO T 105 and shall be as follows: minimum 38 percent aluminum oxide (Al_2O_3), maximum 42 percent calcium oxide (CaO), maximum 1 percent magnesium oxide (MgO), maximum 0.4 percent sulfur trioxide (SO_3), maximum 1 percent loss on ignition, and maximum 3.5 percent insoluble residue.

1001.02 Uniformity of Color. Cement contained in single loads or in shipments of several loads to the same project shall not have visible differences in color.

1001.03 Mixing Brands and Types. Different brands or different types of cement from the same manufacturing plant, or the same brand or type from different plants shall not be mixed or used alternately in the same item of construction unless approved by the Engineer.

1001.04 Storage. Cement shall be stored and protected against damage, such as dampness which may cause partial set or hardened lumps. Different brands or different types of cement from the same manufacturing plant, or the same brand or type from different plants shall be kept separate.

SECTION 1002. WATER

1002.01 General. Water which has been approved by the Illinois Department of Public Health for drinking or ordinary household use may be accepted without being tested. All other sources must be approved by the Engineer.

1002.02 Quality. Water used with cement in concrete or mortar and water used for curing concrete shall be clean, clear, free from sugar, and shall be according to the following.

(a) Acidity and alkalinity when tested according to AASHTO T 26.

- (1) Acidity -- 0.1 Normal NaOH 2 ml max.*
 - (2) Alkalinity -- 0.1 Normal HCl 10 ml max.*
- *To neutralize 200 ml sample.

(b) Solids when tested according to the following.

- (1) Organic (AASHTO T 26)..... 0.02% max.
- (2) Inorganic (AASHTO T 26) 0.30% max.
- (3) Sulfate (SO₄) (ASTM D 516-82) 0.05% max.
- (4) Chloride (ASTM D 512) 0.06% max.

(c) The following tests shall be performed on the water sample and on deionized water. The same cement and sand shall be used for both tests.

- (1) Unsoundness (ASTM C 151).
- (2) Initial and Final Set Time (ASTM C 266).
- (3) Strength (ASTM C 109).

The test results for the water sample shall not deviate from the test results for the deionized water, except as allowed by the precision in the test method.

1002.03 Water Intake. Water from shallow, muddy, or marshy surfaces shall not be used. The intake of the pipeline shall be enclosed to exclude silt, mud, grass, and other solid materials; and there shall be a minimum depth of 2 ft (600 mm) of water below the intake at all times.

SECTION 1003. FINE AGGREGATES

1003.01 Materials. Fine aggregate materials shall be according to the following.

- (a) Description. The natural and manufactured materials used as fine aggregate are defined as follows.
 - (1) Sand. Sand shall be the fine granular material resulting from the natural disintegration of rock. Sand produced from deposits simultaneously with, and by the same operations as, gravel coarse aggregate may contain crushed particles in the quantity resulting normally from the crushing and screening of oversize particles.
 - (2) Silica Sand. Silica sand shall be composed of not less than 99.5 percent silica (SiO_2).
 - (3) Stone Sand. Stone sand shall be produced by washing, or processing by air separation, the fine material resulting from crushing rock quarried from undisturbed, consolidated deposits, or crushing gravel. The acceptance and use of crushed gravel stone sand shall be according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Crushed Gravel Producer Self-Testing Program".
 - (4) Chats. Chats shall be the tailings resulting from the separation of metals from rocks in which they occur.
 - (5) Wet Bottom Boiler Slag. Wet bottom boiler slag shall be the hard, angular by-product of the combustion of coal in wet bottom boilers.
 - (6) Slag Sand. Slag sand shall be the graded product resulting from the screening of air cooled blast furnace slag. Air cooled blast furnace slag shall be the nonmetallic product, consisting essentially of silicates and alumino-silicates of lime and other bases, which is developed in a molten condition simultaneously with iron in a blast furnace.

The acceptance and use of air cooled blast furnace slag sand shall be according to the current Bureau of Materials and Physical Research's Policy Memoranda, "Crushed Slag Producer Certification and Self-Testing Program" and "Slag Producer Self-Testing Program".

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 - (7) Granulated Slag Sand. Granulated slag sand shall be the graded product resulting from the screening of granulated slag. Granulated slag shall be the nonmetallic product, consisting essentially of silicates and alumino-silicates of lime and other bases, which is developed in a molten condition simultaneously with iron in a blast furnace. Granulated slag sand is formed by introducing a large volume of water under high pressure into the molten slag.
 - (8) Steel Slag Sand. Steel slag sand shall be the graded product resulting from the screening of crushed steel slag. Crushed steel slag shall be the nonmetallic product which is developed in a molten condition

simultaneously with steel in an open hearth, basic oxygen, or electric furnace. The acceptance and use of steel slag sand shall be according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Slag Producer Self-Testing Program".

- (9) Crushed Concrete Sand. Crushed concrete sand shall be the angular fragments resulting from crushing portland cement concrete by mechanical means. The acceptance and use of crushed concrete sand shall be according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Recycling Portland Cement Concrete Into Aggregate".
- (10) Construction and Demolition Debris Sand. Construction and demolition debris sand shall be the angular fragments resulting from mechanical crushing/screening of unpainted exterior brick, mortar, and/or concrete with small amounts of other materials. Construction and demolition debris sand shall be according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Construction and Demolition Debris Sand as a Fine Aggregate for Trench Backfill".
- (b) Quality. The fine aggregate shall meet the quality standards listed in the following table. Except for the minus No. 200 (75 μ m) sieve material, all fine aggregate shall meet specified quality requirements before being proportioned for mix or combined to adjust gradation. The blended materials shall meet the minus No. 200 (75 μ m) sieve requirements.

FINE AGGREGATE QUALITY			
QUALITY TEST	CLASS		
	A	B	C
Na ₂ SO ₄ Soundness 5 Cycle, Illinois Modified AASHTO T 104, % Loss max.	10	15	20
Minus No. 200 (75 μ m) Sieve Material, Illinois Modified AASHTO T 11, % max. ^{4/}	3	6 ^{1/}	10 ^{1/}
Organic Impurities Check, Illinois Modified AASHTO T 21	Yes ^{2/}	---	---
Deleterious Materials: ^{3/ 5/}			
Shale, % max.	3.0	3.0	---
Clay Lumps, % max.	1.0	3.0	---
Coal, Lignite, & Shells, % max.	1.0	3.0	---
Conglomerate, % max.	3.0	3.0	---
Other Deleterious, % max.	3.0	3.0	---
Total Deleterious, % max.	3.0	5.0	---

1/ Does not apply to Gradations FA 20 or FA 21.

2/ Applies only to Sand. Sand exceeding the colorimetric test standard of 11 (Illinois Modified AASHTO T 21) will be checked for mortar making properties according to the Illinois Modified AASHTO T 71, and shall develop a compressive strength at the age of 14 days when using Type I or II Cement of not less than 95 percent of the comparable standard.

- 3/ Applies only to sand.
- 4/ Fine aggregate used for hot-mix asphalt (HMA) shall not contain more than three percent clay (2 micron or smaller) particles as determined by Illinois Modified AASHTO T 88.
- 5/ Tests shall be run according to Illinois Test Procedure 204.
- (c) Gradation. All aggregates shall be produced according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Aggregate Gradation Control System".

The gradations prescribed may be manufactured by any suitable commercial process and by the use of any sizes or shapes of plant screen openings necessary to produce the sizes within the limits of the sieve analysis specified.

The gradation of the material from any one source shall be reasonably uniform and shall not be subject to the extreme percentages of gradation represented by the tolerance limits of the various sieve sizes.

The gradation numbers and corresponding gradation limits are listed in the following tables.

FINE AGGREGATE GRADATIONS											
Grad No.	Sieve Size and Percent Passing										
	3/8	No. 4	No. 8 ^{4/}	No. 10	No. 16	No. 30 ^{5/}	No. 40	No. 50	No. 80	No. 100	No. 200 ^{1/}
FA 1	100	97±3			65±20			16±13		5±5	
FA 2	100	97±3			65±20			20±10		5±5	
FA 3	100	97±3		80±15			50±20		25±15		3±3
FA 4	100				5±5						
FA 5	100	92±8								20±20	15±15
FA 6		92±8 ^{2/}								20±20	6±6
FA 7		100		97±3			75±15		35±10		3±3
FA 8			100				60±20			3±3	2±2
FA 9			100					30±15		5±5	
FA 10				100			90±10		60±30		7±7
FA 20	100	97±3	80±20		50±15			19±11		10±7	4±4
FA 21 ^{3/}	100	97±3	80±20		57±18			30±10		20±10	9±9
FA 22	100	^{6/}	^{6/}		8±8						2±2

FINE AGGREGATE GRADATIONS (Metric)											
Grad No.	Sieve Size and Percent Passing										
	9.5 mm	4.75 mm	2.36 mm ^{4/}	2.00 mm	1.18 mm	600 μm ^{5/}	425 μm	300 μm	180 μm	150 μm	75 μm ^{1/}
FA 1	100	97±3			65±20			16±13		5±5	
FA 2	100	97±3			65±20			20±10		5±5	
FA 3	100	97±3		80±15			50±20		25±15		3±3
FA 4	100				5±5						
FA 5	100	92±8								20±20	15±15
FA 6		92±8 ^{2/}								20±20	6±6
FA 7		100		97±3			75±15		35±10		3±3
FA 8			100				60±20			3±3	2±2
FA 9			100					30±15		5±5	
FA 10				100			90±10		60±30		7±7
FA 20	100	97±3	80±20		50±15			19±11		10±7	4±4
FA 21 ^{3/}	100	97±3	80±20		57±18			30±10		20±10	9±9
FA 22	100	6/	6/		8±8						2±2

- 1/ Subject to maximum percent allowed in Fine Aggregate Quality Table.
 - 2/ 100 percent shall pass the 1 in. (25 mm) sieve, except that for bedding material 100 percent shall pass the 3/8 in. (9.5 mm) sieve. If 100 percent passes the 1/2 in. (12.5 mm) sieve, the No. 4 (4.75 mm) sieve may be 75 ± 25.
 - 3/ For all HMA mixtures. When used, either singly or in combination with other sands, the amount of material passing the No. 200 (75 μm) sieve (washed basis) in the total sand fraction for mix design shall not exceed ten percent.
 - 4/ For each gradation used in HMA, the aggregate producer shall set the midpoint percent passing, and the Department will apply a range of ±15 percent. The midpoint shall not be changed without Department approval.
 - 5/ For each gradation used in HMA, the aggregate producer shall set the midpoint percent passing, and the Department will apply a range of ±13 percent. The midpoint shall not be changed without Department approval.
 - 6/ For the fine aggregate gradation FA 22, the aggregate producer shall set the midpoint percent passing, and the Department will apply a range of ± ten percent. The midpoint shall not be changed without Department approval.
- (d) Incompatibility. Incompatibility of any of the gradations or combinations of gradations permitted resulting in unworkable mixtures, nonadherence to the final mix gradation limits, or any other indication of incompatibility shall be just cause for rejection of one or both of the sizes.

- (e) Storage of Fine Aggregate. Sites for storage of all fine aggregates shall be grubbed and cleaned prior to storing the material.

Stockpiles shall be built according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Aggregate Gradation Control System" and the following.

- (1) Fine aggregate of various gradations and from different sources shall be stockpiled separately.
- (2) Stockpiles shall be separated to prevent intermingling at the base. If partitions are used, they shall be of sufficient heights to prevent intermingling.
- (3) Fine aggregates for portland cement concrete and HMA shall be handled in and out of the stockpiles in such a manner that will prevent contamination, segregation, and degradation.

At the time of use, the fine aggregate shall be free from frozen material, material used to caulk rail cars, and all foreign materials which may have become mixed during transportation and handling.

- (f) Shipping Tickets. Shipping tickets for the material shall be according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Designation of Aggregate Information on Shipping Tickets".

1003.02 Fine Aggregate for Portland Cement Concrete and Mortar. The aggregate shall be according to Article 1003.01 and the following.

- (a) Description. The fine aggregate shall consist of washed sand, washed stone sand, or a blend of washed sand and washed stone sand approved by the Engineer. Stone sand produced through an air separation system approved by the Engineer may be used in place of washed stone sand.
- (b) Quality. The fine aggregate for portland cement concrete shall meet Class A Quality, except that the minus No. 200 (75 μ m) sieve Illinois Modified AASHTO T 11 requirement in the Fine Aggregate Quality Table shall not apply to washed stone sand or any blend of washed stone sand and washed sand approved by the Engineer. The fine aggregate for masonry mortar shall meet Class A Quality.
- (c) Gradation. The washed sand for portland cement concrete shall be Gradation FA 1 or FA 2. Washed stone sand for portland cement concrete, which includes any blend with washed sand, shall be Gradation FA 1, FA 2, or FA 20. Fine aggregate for masonry mortar shall be Gradation FA 9.
- (d) Use of Fine Aggregates. The blending, alternate use, and/or substitution of fine aggregates from different sources for use in portland cement concrete will not be permitted without the approval of the Engineer. Any blending shall be by interlocked mechanical feeders at the aggregate source or concrete plant. The blending shall be uniform, and the equipment shall be approved by the Engineer.

1003.03 Fine Aggregate for Hot-Mix Asphalt (HMA). The aggregate shall be according to Article 1003.01 and the following.

- (a) Description. Fine aggregate for HMA shall consist of sand, stone sand, chats, slag sand, or steel slag sand. For gradation FA 22, uncrushed material will not be permitted.
- (b) Quality. The fine aggregate for all HMA shall be Class B Quality or better.
- (c) Gradation. The fine aggregate gradation for all HMA shall be FA 1, FA 2, FA 20, FA 21, or FA 22.

Gradation FA 1, FA 2, or FA 3 shall be used when required for prime coat aggregate application for HMA.

1003.04 Fine Aggregate for Bedding, Trench Backfill, Porous Granular Backfill, Sand Backfill for Underdrains, and French Drains. The aggregate shall be according to Article 1003.01 and the following.

- (a) Description. The fine aggregate shall consist of sand, stone sand, chats, wet bottom boiler slag, slag sand, or granulated slag sand. Crushed concrete sand and construction and demolition debris sand may be used in lieu of the above for trench backfill.
- (b) Quality. The fine aggregate shall be reasonably free from an excess of soft and unsound particles and other objectionable matter.
- (c) Gradation. The fine aggregate gradation for backfill, bedding, and trench backfill for pipe culverts and storm sewers shall be FA 1, FA 2, FA 6, or FA 21.

The fine aggregate gradation for porous granular embankment and backfill, french drains, and sand backfill for underdrains shall be FA 1, FA 2, or FA 20, except the percent passing the No. 200 (75 μ m) sieve shall be 2 ± 2 .

1003.05 Fine Aggregate for Membrane Waterproofing. The aggregate shall be according to Article 1003.01 and the following.

- (a) Description. The fine aggregate shall consist of sand, stone sand, wet bottom boiler slag, slag sand, or chats.
- (b) Quality. The fine aggregate shall meet the Class B Quality Deleterious Count, and when subjected to Illinois Modified AASHTO T 104, the weighted average loss shall not be more than ten percent.
- (c) Gradation. The fine aggregate shall be Gradation FA 8.

1003.06 Fine Aggregate for Controlled Low-Strength Material (CLSM). The aggregate shall be according to Article 1003.01 and the following.

- (a) Description. The fine aggregate shall consist of sand.

- (b) Quality. The fine aggregate shall be reasonably free from an excess of soft and unsound particles and other objectionable matter.
- (c) Gradation. The fine aggregate gradation shall be FA 1 or FA 2. Blending of fine aggregate will not be permitted.

SECTION 1004. COARSE AGGREGATES

1004.01 Materials. Coarse aggregate materials shall be according to the following.

- (a) Description. The natural and manufactured materials used as coarse aggregate are defined as follows.
 - (1) Gravel. Gravel shall be the coarse granular material resulting from the reduction of rock by the action of the elements and having subangular to rounded surfaces. It may be partially crushed.
 - (2) Chert Gravel. Chert gravel shall be the coarse granular material occurring in alluvial deposits resulting from reworking by weathering and erosion of chert bearing geological formations and containing a minimum of 80 percent chert or similar siliceous material.
 - (3) Crushed Gravel. Crushed gravel shall be the product resulting from crushing, by mechanical means, and shall consist entirely of particles obtained by crushing gravel. The acceptance and use of crushed gravel shall be according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Crushed Gravel Producer Self-Testing Program".
 - (4) Crushed Stone. Crushed stone shall be the angular fragments resulting from crushing by mechanical means the following types of rocks quarried from undisturbed, consolidated deposits: granite and similar phanocrystalline igneous rocks, limestone, dolomite, massive metamorphic quartzite, or similar rocks. Dolomite shall be a carbonate rock containing 11.0 percent or more magnesium oxide (MgO). Limestone shall be a carbonate rock containing less than 11.0 percent magnesium oxide (MgO).
 - (5) Wet Bottom Boiler Slag. Wet bottom boiler slag shall be the hard, angular by-product of the combustion of coal in wet bottom boilers.
 - (6) Crushed Slag. Crushed slag shall be the graded product resulting from the processing of air cooled blast furnace slag. Air cooled blast furnace slag shall be the nonmetallic product, consisting essentially of silicates and alumino-silicates of lime and other bases, which is developed in a molten condition simultaneously with iron in a blast furnace. It shall be air cooled and shall have a compact weight (Illinois Modified AASHTO T 19) of not less than 70 lb/cu ft (1100 kg/cu m). The acceptance and use of air-cooled blast furnace slag shall be according

to the current Bureau of Materials and Physical Research's Policy Memoranda, "Crushed Slag Producer Certification and Self-Testing Program" and "Slag Producer Self-Testing Program".

- (7) Crushed Sandstone. Crushed sandstone shall be the angular fragments resulting from crushing, by mechanical means, a cemented sand composed predominantly of quartz grains. Sandstone shall have an Insoluble Residue of 50.0 percent or higher.
 - (8) Crushed Concrete. Crushed concrete shall be the angular fragments resulting from crushing portland cement concrete by mechanical means. The acceptance and use of crushed concrete shall be according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Recycling Portland Cement Concrete Into Aggregate".
 - (9) Chats. Chats shall be the tailings resulting from the separation of metals from the rocks in which they occur.
 - (10) Crushed Steel Slag. Crushed steel slag shall be the graded product resulting from the processing of steel slag. Steel slag shall be the nonmetallic product which is developed in a molten condition simultaneously with steel in an open hearth, basic oxygen, or electric furnace. The acceptance and use of crushed steel slag shall be according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Slag Producer Self-Testing Program".
- (b) Quality. The coarse aggregate shall be according to the quality standards listed in the following table.

COARSE AGGREGATE QUALITY				
QUALITY TEST	CLASS			
	A	B	C	D
Na ₂ SO ₄ Soundness 5 Cycle, Illinois Modified AASHTO T 104 ^{1/} , % Loss max.	15	15	20	25 ^{2/}
Los Angeles Abrasion, Illinois Modified AASHTO T 96, % Loss max.	40 ^{3/}	40 ^{4/}	40 ^{5/}	45
Minus No. 200 (75 µm) Sieve Material, Illinois Modified AASHTO T 11	1.0 ^{6/}	---	2.5 ^{7/}	---
Deleterious Materials ^{10/}				
Shale, % max.	1.0	2.0	4.0 ^{8/}	---
Clay Lumps, % max.	0.25	0.5	0.5 ^{8/}	---
Coal & Lignite, % max.	0.25	---	---	---
Soft & Unsound Fragments, % max.	4.0	6.0	8.0 ^{8/}	---
Other Deleterious, % max.	4.0 ^{9/}	2.0	2.0 ^{8/}	---
Total Deleterious, % max.	5.0	6.0	10.0 ^{8/}	---

1/ Does not apply to crushed concrete.

- 2/ For aggregate surface course and aggregate shoulders, the maximum percent loss shall be 30.
- 3/ For portland cement concrete, the maximum percent loss shall be 45.
- 4/ Does not apply to crushed slag or crushed steel slag.
- 5/ For hot-mix asphalt (HMA) binder mixtures, except when used as surface course, the maximum percent loss shall be 45.
- 6/ For crushed aggregate, if the material finer than the No. 200 (75 μ m) sieve consists of the dust from fracture, essentially free from clay or silt, this percentage may be increased to 2.5.
- 7/ Does not apply to aggregates for HMA binder mixtures.
- 8/ Does not apply to Class A seal and cover coats.
- 9/ Includes deleterious chert. In gravel and crushed gravel aggregate, deleterious chert shall be the lightweight fraction separated in a 2.35 heavy media separation. In crushed stone aggregate, deleterious chert shall be the lightweight fraction separated in a 2.55 heavy media separation. Tests shall be run according to Illinois Modified AASHTO T 113.
- 10/ Test shall be run according to Illinois Test Procedure 203.

All varieties of chert contained in gravel coarse aggregate for portland cement concrete, whether crushed or uncrushed, pure or impure, and irrespective of color, will be classed as chert and shall not be present in the total aggregate in excess of 25 percent by weight (mass).

Aggregates used in Class BS, PS, and PC (superstructure products only) shall contain no more than two percent total by weight (mass) of deleterious materials or substances whose disintegration is accompanied by an increase in volume which may cause spalling of the concrete.

- (c) Gradation. All aggregates shall be produced according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Aggregate Gradation Control System".

The sizes prescribed may be manufactured by any suitable commercial process and by the use of any sizes or shapes of plant screen openings necessary to produce the sizes within the limits of the sieve analysis specified.

The gradation of the material from any one source shall be reasonably close to the gradation specified and shall not be subject to the extreme percentages of gradation represented by the tolerance limits for the various sieve sizes. The gradation numbers and corresponding gradation limits are listed in the following table.

	COARSE AGGREGATE GRADATIONS													
Grad No.	Sieve Size and Percent Passing													
	3 in.	2 1/2 in.	2 in.	1 1/2 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	No. 4	No. 8	No. 16	No. 50	No. 200 ^{1/}	
CA 1	100	95±5	60±15	15±15	3±3									
CA 2		100	95±5		75±15		50±15		30±10		20±15		8±4	
CA 3		100	93±7	55±20	8±8		3±3							
CA 4			100	95±5	85±10		60±15		40±10		20±15		8±4	
CA 5				97±3 ^{2/}	40±25		5±5		3±3					
CA 6				100	95±5		75±15		43±13		25±15		8±4	
CA 7				100	95±5		45±15 ^{3/8/}		5±5					
CA 8				100	97±3	85±10	55±10		10±5		3±3 ^{4/}			
CA 9				100	97±3		60±15		30±15		10±10		6±6	
CA 10					100	95±5	80±15		50±10		30±15		9±4	
CA 11					100	92±8	45±15 ^{5/8/}		6±6		3±3 ^{4/ 6/}			
CA 12						100	95±5	85±10	60±10		35±10			
CA 13						100	97±3	80±10	30±15		3±3 ^{4/}			
CA 14							90±10 ^{7/}	45±20	3±3					
CA 15							100	75±15	7±7		2±2			
CA 16							100	97±3	30±15		2±2 ^{4/}			
CA 17	100								65±20		45±20	20±10	10±5	
CA 18	100				95±5				75±25		55±25	10±10	2±2	
CA 19	100				95±5				60±15		40±15	20±10	10±5	
CA 20							100	92±8	20±10	5±5	3±3			

	COARSE AGGREGATE GRADATIONS (metric)													
Grad No.	Sieve Size and Percent Passing													
	75 mm	63 mm	50 mm	37.5 mm	25 mm	19 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	1.18 mm	300 μm	75 μm ^{1/}	
CA 1	100	95±5	60±15	15±15	3±3									
CA 2		100	95±5		75±15		50±15		30±10		20±15		8±4	
CA 3		100	93±7	55±20	8±8		3±3							
CA 4			100	95±5	85±10		60±15		40±10		20±15		8±4	
CA 5				97±3 ^{2/}	40±25		5±5		3±3					
CA 6				100	95±5		75±15		43±13		25±15		8±4	
CA 7				100	95±5		45±15 ^{3/8/}		5±5					
CA 8				100	97±3	85±10	55±10		10±5		3±3 ^{4/}			
CA 9				100	97±3		60±15		30±15		10±10		6±6	
CA 10					100	95±5	80±15		50±10		30±15		9±4	
CA 11					100	92±8	45±15 ^{5/8/}		6±6		3±3 ^{4/ 6/}			
CA 12						100	95±5	85±10	60±10		35±10		9±4	
CA 13						100	97±3	80±10	30±15		3±3 ^{4/}			
CA 14							90±10 ^{7/}	45±20	3±3					
CA 15							100	75±15	7±7		2±2			
CA 16							100	97±3	30±15		2±2 ^{4/}			
CA 17	100								65±20		45±20	20±10	10±5	
CA 18	100				95±5				75±25		55±25	10±10	2±2	
CA 19	100				95±5				60±15		40±15	20±10	10±5	
CA 20							100	92±8	20±10	5±5	3±3			

1/ Subject to maximum percent allowed in Coarse Aggregate Quality table.

2/ Shall be 100 percent passing the 1 3/4 in. (45 mm) sieve.

- 3/ When using gradation CA 7 for IL-25.0 binder, the percent passing the 1/2 in. (12.5 mm) sieve may also be 35 ± 10 or 15 ± 10 .
- 4/ When used in HMA (High and Low ESAL) mixtures, the percent passing the No. 16 (1.18 mm) sieve for gradations CA 8, CA 11, CA 13, or CA 16 shall be 4 ± 4 percent.
- 5/ When using gradation CA 11 for IL-19.0 and IL-19.0L binder, the percent passing the 1/2 in. (12.5 mm) sieve may also be 15 ± 10 .
- 6/ The No. 16 (1.18 mm) requirement will be waived when CA 11 is used in the manufacture of portland cement concrete.
- 7/ Shall be 100 percent passing the 5/8 in. (16 mm) sieve.
- 8/ When Class BS concrete is to be pumped, the coarse aggregate gradation shall have a minimum of 45 percent passing the 1/2 in. (12.5 mm) sieve. The Contractor may combine two or more coarse aggregate sizes, consisting of CA 7, CA 11, CA 13, CA 14, and CA 16, provided a CA 7 or CA 11 is included in the blend.

Note: When CA 7, CA 8, CA 11, CA 13, CA 14, CA 15, or CA 16 are used under paved median, Notes 3, 4, 5, 6, and 7 shall apply.

- (d) Incompatibility. Incompatibility of any of the gradations or combinations of gradations permitted resulting in unworkable mixtures, nonadherence to the final mix gradation limits, or any other indication of incompatibility shall be just cause for rejection of one or both of the sizes.
- (e) Storage. Sites for stockpiles shall be grubbed and cleaned prior to storing the aggregates.

The stockpiles shall be built according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Aggregate Gradation Control System" and the following.

- (1) Segregation or degradation due to improper stockpiling or loading out of stockpiles shall be just cause for rejecting the material.
- (2) Separate stockpiles shall be provided for the various kinds of aggregates.
- (3) Stockpiles shall be separated to prevent intermingling at the base. If partitions are used, they shall be of sufficient heights to prevent intermingling.
- (4) Coarse aggregates shall be handled in and out of the stockpiles in such a manner that will prevent contamination and degradation.
- (5) Crushed slag or lightweight aggregate for portland cement concrete shall be stockpiled in a moist condition (saturated surface dry or

greater) and the moisture content shall be maintained uniformly throughout the stockpile by periodic sprinkling.

At the time of use, the coarse aggregate shall be free from frozen material, material used to caulk rail cars, and all foreign material which may have become mixed during transportation and handling.

- (f) Shipping Tickets. Shipping tickets for the material shall be according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Designation of Aggregate Information on Shipping Tickets".

1004.02 Coarse Aggregate for Portland Cement Concrete. The aggregate shall be according to Article 1004.01 and the following.

- (a) Description. The coarse aggregate shall be gravel, crushed gravel, crushed stone, crushed concrete, crushed slag, or crushed sandstone.
- (b) Quality. The coarse aggregate shall be Class A quality.
- (c) Gradation. The gradations of coarse aggregate used in the production of portland cement concrete for pavements and structures shall be according to Table 1 of Article 1020.04. Washing equipment will be required where producing conditions warrant.
- (d) Combining Sizes. Each size shall be stored separately and care shall be taken to prevent them from being mixed until they are ready to be proportioned. The Contractor will be permitted to mix more than two sizes of coarse aggregate, provided the separate sizes selected and the proportions used in combining them are approved by the Engineer, and that separate compartments are provided to proportion each size.
- (1) When Class BS concrete is to be pumped, the coarse aggregate gradation shall have a minimum of 45 percent passing the 1/2 in. (12.5 mm) sieve. The Contractor may combine two or more coarse aggregate sizes, consisting of CA 7, CA 11, CA 13, CA 14, and CA 16, provided a CA 7 or CA 11 is included in the blend.
- (2) If the coarse aggregate is furnished in separate sizes, they shall be combined in proportions to provide a uniformly graded coarse aggregate grading within the following limits.

Class of Concrete ^{1/}	Combined Sizes	Sieve Size and Percent Passing						
		2 1/2 in.	2 in.	1 3/4 in.	1 1/2 in.	1 in.	1/2 in.	No. 4
PV ^{2/}	CA 5 & CA 7	---	---	100	98±2	72±22	22±12	3±3
	CA 5 & CA 11	---	---	100	98±2	72±22	22±12	3±3
MS and SC ^{2/}	CA 3 & CA 7	100	95±5	---	---	55±25	20±10	3±3
	CA 3 & CA 11	100	95±5	---	---	55±25	20±10	3±3
	CA 5 & CA 7	---	---	100	98±2	72±22	22±12	3±3
	CA 5 & CA 11	---	---	100	98±2	72±22	22±12	3±3

Class of Concrete ^{1/}	Combined Sizes	Sieve Size (metric) and Percent Passing						
		63 mm	50 mm	45 mm	37.5 mm	25 mm	12.5 mm	4.75 mm
PV ^{2/}	CA 5 & CA 7	---	---	100	98±2	72±22	22±12	3±3
	CA 5 & CA 11	---	---	100	98±2	72±22	22±12	3±3
MS and SC ^{2/}	CA 3 & CA 7	100	95±5	---	---	55±25	20±10	3±3
	CA 3 & CA 11	100	95±5	---	---	55±25	20±10	3±3
	CA 5 & CA 7	---	---	100	98±2	72±22	22±12	3±3
	CA 5 & CA 11	---	---	100	98±2	72±22	22±12	3±3

1/ See Table 1 of Article 1020.04.

2/ Any of the listed combination of sizes may be used.

- (e) Mixing Gravel, Crushed Gravel, Crushed Stone, and Crushed Slag Coarse Aggregates. Two different specified sizes of crushed stone, gravel, and crushed gravel from one source or any two sources may be combined in any consistent ratio in a mix; but the use of alternate batches of crushed stone, gravel, or crushed gravel of any one size or combination of sizes will not be permitted. Coarse aggregates of any one size from different sources shall not be mixed without permission from the Engineer. Crushed slag shall not be combined or mixed with gravel, crushed gravel, or crushed stone aggregates.
- (f) Freeze-Thaw Rating. When coarse aggregate is used to produce portland cement concrete for base course, base course widening, pavement, driveway pavement, sidewalk, shoulders, curb, gutter, combination curb and gutter, median, paved ditch, concrete superstructures on grade such as bridge approach slabs, or their repair using concrete, the gradation permitted will be determined from the results of the Department's Freeze-Thaw Test (Illinois Modified AASHTO T 161). A list of freeze-thaw ratings for all Class A quality coarse aggregate sources will be available. The gradations permitted for each rating shall be as follows.

Freeze-Thaw Rating (Top Size) in. mm	Gradation Permitted
1 1/2 in. (37.5 mm)	Combined CA 5 & CA 7, Combined CA 5 & CA 11, CA 7, or CA 11
1 in. (25 mm)	CA 7 or CA 11
3/4 in. (19 mm)	CA 11
1/2 in. (12.5 mm)	CA 13, CA 14, or CA 16
NON-ACC	Not Acceptable

Additional requirements may be placed on coarse aggregates when used in continuously reinforced concrete pavement. Such requirements will be stipulated on the most recent Freeze-Thaw Rating List.

If lightweight aggregate is specified for structures, it shall be according to ASTM C 330, the second paragraph of Article 1004.01(c), and Articles 1004.01(d) and 1004.01(e). Lightweight aggregate of any one size from different sources shall not be mixed without permission of the Engineer. Lightweight aggregate may be combined or mixed with gravel, crushed gravel, or crushed stone.

1004.03 Coarse Aggregate for Hot-Mix Asphalt (HMA). The aggregate shall be according to Article 1004.01 and the following.

- (a) Description. The coarse aggregate for HMA shall be according to the following table.

Use	Mixture	Aggregates Allowed
Class A	Seal or Cover	Gravel Crushed Gravel Crushed Stone Crushed Sandstone Crushed Slag (ACBF) Crushed Steel Slag Crushed Concrete
HMA All Other	Stabilized Subbase or Shoulders	Gravel Crushed Gravel Crushed Stone Crushed Sandstone Crushed Slag Crushed Concrete The coarse aggregate for stabilized subbase, if approved by the Engineer, may be produced by blending aggregates according to Article 1004.04(a).
HMA High ESAL Low ESAL	IL-25.0, IL-19.0, or IL-19.0L	Crushed Gravel Crushed Stone Crushed Sandstone Crushed Slag (ACBF)
HMA High ESAL Low ESAL	C Surface IL-12.5, IL-9.5, or IL-9.5L	Crushed Gravel Crushed Stone Crushed Sandstone Crushed Slag (ACBF) Crushed Steel Slag (except when used as leveling binder)
HMA High ESAL	D Surface IL-12.5 or IL-9.5	Crushed Gravel Crushed Stone (other than Limestone) Crushed Sandstone Crushed Slag (ACBF) Crushed Steel Slag (except when used as leveling binder) Limestone may be used in Mixture D if blended by volume in the following coarse aggregate percentages: Up to 25% Limestone with at least 75% Dolomite. Up to 50% Limestone with at least 50% any aggregate listed for Mixture D except Dolomite. Up to 75% Limestone with at least 25% Crushed Slag (ACBF) or Crushed Sandstone.

Use	Mixture	Aggregates Allowed
HMA High ESAL	E Surface IL-12.5 or IL-9.5	<p>Crushed Gravel Crushed Stone (other than Limestone and Dolomite) Crushed Sandstone</p> <p>No Limestone.</p> <p>Dolomite may be used in Mixture E if blended by volume in the following coarse aggregate percentages: Up to 75% Dolomite with at least 25% Crushed Sandstone, Crushed Slag (ACBF), or Crushed Steel Slag. When Crushed Slag (ACBF) or Crushed Steel Slag are used in the blend, the blend shall contain a minimum of 25% to a maximum of 75% of either Slag by volume. Up to 50% Dolomite with at least 50% of any aggregate listed for Mixture E.</p> <p>If required to meet design criteria, Crushed Gravel or Crushed Stone (other than Limestone or Dolomite) may be blended by volume in the following coarse aggregate percentages: Up to 75% Crushed Gravel or Crushed Stone (other than Limestone or Dolomite) with at least 25% Crushed Sandstone, Crushed Slag (ACBF), or Crushed Steel Slag. When Crushed Slag (ACBF) or Crushed Steel Slag are used in the blend, the blend shall contain a minimum of 25% to a maximum of 50% of either Slag by volume.</p>
HMA High ESAL	F Surface IL-12.5 or IL-9.5	<p>Crushed Sandstone</p> <p>No Limestone.</p> <p>Crushed Gravel or Crushed Stone (except Limestone) may be used in Mixture F if blended by volume in the following coarse aggregate percentages: Up to 50% Crushed Gravel or Crushed Stone with at least 50% Crushed Sandstone, Crushed Slag (ACBF), or Crushed Steel Slag. When Crushed Slag (ACBF) or Crushed Steel Slag are used in the blend, the blend shall contain a minimum of 50% to a maximum of 75% of either Slag by volume.</p>

- (b) Quality. For surface courses and binder courses when used as surface course, the coarse aggregate shall be Class B quality or better. For Class A (seal or cover coat), and other binder courses, the coarse aggregate shall be Class C quality or better. For All Other courses, the coarse aggregate shall be Class D quality or better.

- (c) Gradation. The coarse aggregate gradations shall be as listed in the following table.

Use	Size/Application	Gradation No.
Class A-1, 2, & 3	3/8 in. (10 mm) Seal	CA 16 or CA 20
Class A-1	1/2 in. (13 mm) Seal	CA 15
Class A-2 & 3	Cover	CA 14
HMA High ESAL	IL-25.0 IL-19.0 IL-12.5 IL-9.5	CA 7 ^{1/} or CA 8 ^{1/} CA 11 ^{1/} CA 16 and/or CA 13 CA 16
HMA Low ESAL	IL-19.0L IL-9.5L	CA 11 ^{1/} CA 16
HMA All Other	Stabilized Subbase or Shoulders	CA 6 ^{2/} , CA 10, or CA 12

1/ CA 16 or CA 13 may be blended with the gradations listed.

2/ CA 6 will not be permitted in the top lift of shoulders.

1004.04 Coarse Aggregate for Granular Embankment Special; Granular Subbase; Stabilized Subbase; and Aggregate Base, Surface, and Shoulder Courses. The aggregate shall be according to Article 1004.01 and the following.

- (a) Description. The coarse aggregate shall be gravel, crushed gravel, crushed stone, crushed concrete, crushed slag, or crushed sandstone, except gravel shall not be used for subbase granular material, Type C.

The coarse aggregate for stabilized subbase, aggregate base course, and aggregate shoulders, if approved by the Engineer, may be produced by blending aggregates from more than one source, provided the method of blending results in a uniform product. The components of a blend need not be of the same kind of material. The source of material or blending proportions shall not be changed during the progress of the work without written permission from the Engineer. Where a natural aggregate is deficient in fines, the material added to make up deficiencies shall be a fine aggregate of Class C quality or higher according to Section 1003 and/or mineral filler meeting the requirements of Article 1011.01.

- (b) Quality. The coarse aggregate shall be Class D Quality or better.

- (c) Gradation. The coarse aggregate gradation shall be used as follows.

Use	Gradation
Granular Embankment, Special	CA 6 or CA 10 ^{1/}
Granular Subbase: Subbase Granular Material, Ty. A	CA 6 or CA 10 ^{2/}
Subbase Granular Material, Ty. B	CA 6, CA 10, CA 12, or CA 19 ^{2/}
Subbase Granular Material, Ty. C	CA 7, CA 11, or CA 5 & CA 7 ^{3/}
Stabilized Subbase	CA 6 or CA 10 ^{4/}
Aggregate Base Course	CA 6 or CA 10 ^{2/}
Aggregate Surface Course: Type A	CA 6 or CA 10 ^{1/}
Type B	CA 6, CA 9, or CA 10 ^{5/}
Aggregate Shoulders	CA 6 or CA 10 ^{2/}

- 1/ Gradation CA 2, CA 4, CA 9, or CA 12 may be used if approved by the Engineer.
- 2/ Gradation CA 2 or CA 4 may be used if approved by the Engineer.
- 3/ If the CA 5 and CA 7 blend is furnished, proper mixing will be required either at the source or at the jobsite according to Article 1004.02(d).
- 4/ Gradation CA 2, CA 4, or CA 12 may be used if approved by the Engineer.
- 5/ Gradation CA 4 or CA 12 may be used if approved by the Engineer.
- (d) Plasticity. All material shall comply with the plasticity index requirements listed below. The plasticity index requirement for crushed gravel, crushed stone, and crushed slag may be waived if the ratio of the percent passing the No. 200 (75 µm) sieve to that passing the No. 40 (425 µm) sieve is 0.60 or less.

Use	Plasticity Index - Percent ^{1/}	
	Gravel	Crushed Gravel, Stone, & Slag
Granular Embankment, Special	0 to 6	0 to 4
Granular Subbase: Subbase Granular Material, Ty. A	0 to 9	---
Subbase Granular Material, Ty. B	0 to 9	---
Stabilized Subbase	0 to 9	0 to 9
Aggregate Base Course	0 to 6	0 to 4
Aggregate Surface Course: Type A	2 to 9	---
Type B ^{2/}	2 to 9	---
Aggregate Shoulders	2 to 9	---

- 1/ Plasticity Index shall be determined by the method given in AASHTO T 90. Where shale in any form exists in the producing ledges, crushed stone samples shall be soaked a minimum of 18 hours before processing for plasticity index or minus No. 40 (425 µm) material.

When clay material is added to adjust the plasticity index, the clay material shall be in a minus No. 4 (4.75 mm) sieve size.

- 2/ When Gradation CA 9 is used, the plasticity index requirement will not apply.

1004.05 Coarse Aggregate for Blotter, Embankment, Backfill, Trench Backfill, Bedding, and French Drains. The aggregate shall be according to Article 1004.01 and the following.

- (a) Description. The coarse aggregate shall be gravel, crushed gravel, crushed stone, crushed concrete, crushed slag, chats, crushed sandstone, or wet bottom boiler slag.
- (b) Quality. The coarse aggregate shall consist of sound durable particles reasonably free of objectionable deleterious material.
- (c) Gradation. The coarse aggregate gradation shall be as follows.
 - (1) Blotter CA 15
 - (2) Nonporous Granular Embankment and Backfill CA 17
 - (3) Porous Granular Embankment and Backfill, and French Drains CA 18
 - (4) Backfill, Bedding, and Trench Backfill for
Pipe Culverts and Storm Sewers CA 6, CA 10, and CA 18

SECTION 1005. STONE AND BROKEN CONCRETE FOR EROSION PROTECTION, SEDIMENT CONTROL, AND ROCKFILL

1005.01 Stone for Erosion Protection, Sediment Control, and Rockfill. The material will be sampled and inspected according to the current Bureau of Materials and Physical Research’s Policy Memorandum, “Inspection of Stone for Erosion Protection, Sediment Control, and Rockfill”. The material shall be according to the following.

- (a) Description. The material shall be stone, quarried from undisturbed, consolidated deposits (ledges) of rock reasonably free of shale and shaly stone. The ledges shall be sufficiently thick to produce the desired dimensions. The stone shall be reasonably free of laminations, seams, cracks, and other structural defects or imperfections tending to destroy its resistance to weather. Field stone or boulders will not be accepted.

Bedding material shall be crushed stone, crushed gravel, crushed sandstone, or crushed slag meeting the requirements of Article 1004.01(a).
- (b) Quality. The stone shall be according to the following.

- (1) Stone for Erosion Protection or Sediment Control. The material shall be quarried from ledges meeting the quality designations listed in the following table.

QUALITY OF STONE FOR EROSION PROTECTION AND SEDIMENT CONTROL		
QUALITY TEST	QUALITY A ^{1/ 2/ 3/}	QUALITY B ^{1/}
Na ₂ SO ₄ Soundness 5 Cycle, Illinois Modified AASHTO T 104 ^{1/} Max. % Loss	15	25

- 1/ Elongated pieces (length is greater than five times the average thickness) shall not exceed ten percent by weight.
- 2/ The stone, when checked in a full gradation product, shall have a specific gravity (dry) greater than 2.450, as determined by the Department.
- 3/ The stone shall be reasonably free of chert.

In addition to the above quality requirements, crushed slag used as a bedding material shall also meet the requirements in Illinois Test Procedure 202 according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Crushed Slag Producer Certification and Self-Testing Program".

- (2) Stone for Rockfill. The material shall be quarried from ledges consisting of sound, durable rock reasonably free of objectionable, deleterious material as determined by the Department.
- (c) Gradation. The stone shall be according to the following.
- (1) Stone for Erosion Protection or Sediment Control. The material shall meet the gradation limits listed in the following tables. All gradations produced shall be well graded.

BEDDING MATERIAL GRADATIONS					
Grad. No.	Percent Passing Sieves				
	4 in.	3 in.	2 in.	1 1/2 in.	No. 4
RR 1		100		53±23	8±8
RR 2	100		53±23		8±8

BEDDING MATERIAL GRADATIONS (METRIC)					
Grad. No.	Percent Passing Sieves				
	100 mm	75 mm	50 mm	37.5 mm	4.75 mm
RR 1		100		53±23	8±8
RR 2	100		53±23		8±8

EROSION PROTECTION AND SEDIMENT CONTROL GRADATIONS														
Grad. No.	Percent Passing Rock Size (lb)													
	1000 ^{1/}	600 ^{1/}	400 ^{1/}	300	170	150 ^{1/}	90	50 ^{1/}	40	12	10	6	3	1
RR 3								100			50±20			8±8
RR 4						100			50±20					8±8
RR 5			100				50±20						8±8	
RR 6		100			50±20							8±8		
RR 7	100			50±20						8±8				

EROSION PROTECTION AND SEDIMENT CONTROL GRADATIONS (METRIC)														
Grad. No.	Percent Passing Rock Size (kg)													
	455 ^{1/}	270 ^{1/}	180 ^{1/}	135	75	70 ^{1/}	40	20 ^{1/}	18	5	4	3	1	0.5
RR 3								100			50±20			8±8
RR 4						100			50±20					8±8
RR 5			100				50±20						8±8	
RR 6		100			50±20							8±8		
RR 7	100			50±20						8±8				

1/ A maximum of 15 percent of the total test sample by weight may be oversize material. Each oversize piece shall not exceed the maximum size of the gradation by more than 20 percent.

(2) Stone for Rockfill. The material may be shot rock, primary crusher run, or other specified gradations approved by the Department.

(d) Shipping Tickets. Shipping tickets for the material shall be according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Designation of Aggregate Information on Shipping Tickets".

1005.02 Broken Concrete for Erosion Control. The material shall be made from newly broken, sound concrete pavement or other suitable concrete debris from demolished concrete construction having a minimum thickness of 6 in. (150 mm) between unbroken surfaces. Concrete showing excessive popping, spalling, cracking, or any other type of disintegration indicating poor resistance to weathering will not be acceptable. No reinforcing steel or other such material shall be protruding from the broken pieces. The gradation or sizing of the pieces shall be according to Article 1005.01(c).

1005.03 Reserved.

SECTION 1006. METALS

1006.01 Corrugated Steel Pipe and Corrugated Steel Pipe Arch. The pipe and arch shall be according to the following.

- (a) Corrugated Steel Pipe and Corrugated Steel Pipe Arch; Bituminous Coated Corrugated Steel Pipe and Bituminous Coated Corrugated Steel Pipe Arch; Perforated Corrugated Steel Pipe; Zinc and Aramid Fiber Composite Coated Corrugated Steel Pipe; and Aluminized Steel Type 2 Corrugated Pipe and Corrugated Pipe Arch. The pipe and arch shall be according to AASHTO M 36 and the following.
 - (1) Bituminous coatings shall be according to AASHTO M 190, Type A. Bituminous coating for the connecting bands will not be required. Any bituminous coating damaged shall be repaired.
 - (2) The perforations in Perforated Corrugated Steel Pipe shall have a nominal diameter of 3/16 in. (5 mm) when fine aggregate is used for backfill.
 - (3) The sawed or cut ends of all corrugated steel pipe shall be coated according to the methods described in the Repair of Damaged Coatings in AASHTO M 36.
 - (4) Round pipes 48 in. (1200 mm) in diameter and smaller may be fabricated with the smooth sleeve-type coupler listed in AASHTO M 36. The gasket material on the coupler shall be polyisoprene or equal with a durometer hardness of 45 ± 5 (ASTM D 2240, Shore A).
- (b) Precoated Galvanized Corrugated Steel Pipe and Precoated Galvanized Corrugated Steel Pipe Arch. The precoated steel sheets used to fabricate these items shall be according to AASHTO M 246, Grade 250/250. The precoated pipe and pipe arch shall be according to AASHTO M 245. The sawed or cut ends of corrugated pipe shall be coated according to the methods described in the Repair of Damaged Coatings in AASHTO M 245. Precoating for the connecting bands will not be required. When the smooth sleeve-type coupler is used, the gasket material on the coupler shall be polyisoprene or equal with a durometer hardness of 45 ± 5 (ASTM D 2240, Shore A).

1006.02 Corrugated Structural Plate Pipe, Pipe Arches, and Arches. Corrugated steel structural plate pipe, pipe arches, and arches that are fabricated and erected in sections shall be according to AASHTO M 167. Corrugated aluminum alloy structural plate pipe, pipe arches, and arches that are fabricated and erected in sections shall be according to AASHTO M 219.

1006.03 Corrugated Aluminum Alloy Pipe and Corrugated Aluminum Alloy Pipe Arch. Corrugated Aluminum Alloy Pipe and Corrugated Aluminum Alloy Pipe Arch; Bituminous Coated Corrugated Aluminum Alloy Pipe and Bituminous Coated Corrugated Aluminum Alloy Pipe Arch; and Perforated Corrugated Aluminum Alloy Pipe. The pipe and arch shall be according to AASHTO M 196 and the following.

- (a) The lot number may be shown instead of the processing date.
- (b) Bituminous coatings shall be according to AASHTO M 190, Type A. Bituminous coating for the connecting bands will not be required. Any bituminous coating damaged shall be repaired.
- (c) The perforations in Perforated Corrugated Aluminum Alloy Pipe shall have a nominal diameter of 3/16 in. (5 mm) when fine aggregate is used for backfill.
- (d) Round pipes 48 in. (1200 mm) in diameter and smaller may be fabricated with the smooth sleeve-type coupler listed in AASHTO M 36. The gasket material on the coupler shall be polyisoprene or equal with a durometer hardness of 45 ± 5 (ASTM D 2240, Shore A).

1006.04 Structural Steel. Structural steel shall be according to AASHTO M 270 Grade 36 (M 270M Grade 250), or M 270 Grade 50 (M 270M Grade 345). Grade 36 (Grade 250) shall be considered the default when not specified otherwise. When weathering steel is specified, the structural steel shall be according to AASHTO M 270 Grade 50W (M 270M Grade 345W). Bar stock according to ASTM A 576, with similar mechanical properties and chemical composition, may be used.

- (a) Rollers. Rollers shall be made from any of the following materials.
 - (1) Structural steel having a minimum tensile strength of 58,000 psi (400,000 kPa), a minimum yield point of 36,000 psi (250,000 kPa), a minimum elongation of 20 percent, and according to all other respects to AASHTO M 270 Grade 36 (M 270M, Grade 250).
 - (2) Rollers, 9 in. (225 mm) or less in diameter, may be made from cold finished bars according to AASHTO M 169, Grades 1016 to 1030 inclusive.
 - (3) Forgings shall be according to AASHTO M 102, Class C.
- (b) Pins. Pins shall be according to SAE 8620 Material.

1006.05 Metal Piling and Steel Casing. Metal shell pile, steel pile, sheet pile, and permanent steel casing shall be according to the following.

- (a) Metal Shell Piling. All shells without taper shall be according to ASTM A 252, Grades 2 or 3. The steel for fluted, tapered shells shall have a minimum tensile strength of 50,000 psi (345,000 kPa).
- (b) Steel Piling. Steel piling shall be according to AASHTO M 270, Grade 36 or Grade 50 (M 270M, Grade 250 or Grade 345).
- (c) Sheet Piling. Steel sheet piling shall be according to AASHTO M 202 (M 202M).

- (d) Steel Casing. Permanent steel casing shall be according to ASTM A 252, Grade 2, produced by electric seam, butt, or spiral welding. The minimum wall thickness shall be as required to resist the anticipated installation and dewatering stresses, as determined by the Contractor, but shall be a minimum of 1/4 in. (6 mm).
- (e) Pile Shoes. Pile shoes shall be cast in one-piece steel according to either ASTM A 148 Grade 90-60 (Grade 620-415) or AASHTO M 103 (M 103M) Grade 65-35 (Grade 450-240) and shall provide full bearing for the piles. They shall have sufficient flange and continuous web vertical back-ups to assure proper alignment and fitting to the pile. The soil or rock bearing surfaces of the shoes shall be sloped downward towards the web a minimum of 15 degrees, but not to exceed 45 degrees to the horizontal under the flanges. The sloped surfaces of the shoes shall terminate in a manner to form a flat surface not exceeding one-third of the flange width. The minimum weight (mass) of the pile shoes shall be 35 percent of the proposed pile weight (mass), per 1.0 ft (0.3 m) for AASHTO M 103 (M 103M) steel and 30 percent for ASTM A 148 steel.

1006.06 Transverse Tie Rods and Dowel Rods. Transverse tie rods and dowel rods shall be according to the following.

- (a) Transverse Tie Rods. Steel for transverse tie rods shall be according to AASHTO M 227 Grades 70 through 80 (M 227M Grade 485 through 555) or AASHTO M 31 (M 31M) plain bars. After fabrication, the transverse tie assemblies (tie rods, nuts, washers, and sleeves) shall be hot-dipped galvanized according to AASHTO M 232. The small articles may be zinc-coated by the mechanically deposited process according to AASHTO M 298, Class 50. The thickness of the mechanical galvanizing shall not exceed 6 mils (150 μ m).
- (b) Dowel Rods. Steel for dowel rods shall be according to AASHTO M 227 Grades 70 through 80 (M 227M Grades 485 through 555) or AASHTO M 31 (M 31M).

1006.07 Turned and Ribbed Bolts. Low carbon steel turned and ribbed bolts shall be according to ASTM A 307, Grade C.

1006.08 High Strength Steel Bolts, Nuts, and Washers. High strength steel bolts, nuts, and washers shall be according to AASHTO M 164 (M 164M), except as modified by the Specifications for Structural Joints using AASHTO M 164 (M 164M) Bolts, approved by the Research Council on Structural Connections of the Engineering Foundation. The bolts, nuts, and washers shall be galvanized as follows.

- (a) Mechanical Galvanizing. When mechanical galvanizing is specified, the bolts, nuts, and washers shall be zinc coated according to AASHTO M 298, Class 50. The thickness of the zinc coating shall not exceed 6 mils (150 μ m). Nuts shall be tapped oversize according to AASHTO M 291 (M 291M) and shall be according to the supplementary requirements of S1.1 thru S1.2.1 of the same specifications for lubricant and testing. The lubricant shall be tinted to produce a distinct contrast with the nut.

- (b) Hot Dip Galvanizing. When hot dip galvanizing is specified, the bolts, nuts, and washers shall be zinc coated according to AASHTO M 232.
- (c) Weathering Steel. When unpainted weathering steel is specified, the bolts shall be according to AASHTO M 164 (M 164M) Type 3.

1006.09 Anchor Bolts and Rods. All anchor bolts shall be of the type and dimensions as shown on the plans. The minimum bend radius shall be four times the nominal diameter. All headed anchor bolts, non-headed anchor rods, and nuts shall be according to ASTM F 1554 Grade 36 (Grade 250), Grade 55 (Grade 380), or Grade 105 (Grade 725). Stud bolts shall be according to ASTM A 354 Grade BC and shall meet the same toughness requirements of S5 and Table S2.1 of ASTM F 1554.

Washers and nuts shall proportionally match with the hardness of the anchor bolt, stud, or rod. For ASTM F 1554 Grade 36 (Grade 250) or Grade 55 (Grade 380) anchor rods or bolts, washers shall be according to ASTM F 844, and nuts shall be according to AASHTO M 291 Grade A. For ASTM F 1554 Grade 105 (Grade 725) bolts or ASTM A 354 stud bolts, washers shall be according to AASHTO M 293 Type 1 or Type 3, and nuts shall be according to AASHTO M 291 Grade DH or DH3.

Anchor bolts and rods, conforming to ASTM F 1554 shall satisfy the applicable specification for the grade specified and the supplemental Charpy V-Notch (CVN) toughness requirements herein specified. Grade 55 (Grade 380) anchor bolts and rods shall satisfy Supplemental Requirement S4 and Table S1.1 of ASTM F 1554. Grade 105 (Grade 725) anchor bolts and rods shall satisfy Supplemental Requirement S5 and Table S1.2 of ASTM F 1554.

Stud bolts conforming to ASTM A 354 shall also satisfy the supplemental (CVN) toughness requirements of S5 and Table S1.2 of ASTM F 1554.

Expansion hook bolts, which are to be used as dowels, shall contain an approved anchoring device providing the following minimum certified proof load according to tensile testing requirements of ASTM E 488 for the specified hook bolt diameter.

HOOK BOLT	PROOF LOAD
5/8 in. (M16)	5000 lb (22 kN)
3/4 in. (M 20)	7500 lb (33 kN)
7/8 in. (M 22)	8000 lb (35 kN)

Welding of anchor bolts and rods is not permitted.

Anchor bolts and rods, nuts, and washers requiring galvanizing shall be hot dipped according to AASHTO M 232, Class C.

1006.10 Concrete Reinforcement Bars, Fabric, and Strand. All fabrication shall be done at the mill or shop prior to shipment.

At the time of shipment, the surface of all reinforcement bars, fabric, and prestressing strands shall be free from loose mill scale, dirt, oil, grease, or other

foreign substances. A light coating of rust, which may form during storage under acceptable conditions at the mill or warehouse, will not be deemed cause for rejection. Stocks of reinforcement bars, fabric, or strand either at the mill or warehouse, which have not been protected in an adequate manner during storage, will not be accepted.

At the time the bars, fabric, or strands are placed in the work, they shall be free from rust which pits the surface or scales off, dirt, oil, grease, or other foreign substances. A light coating of rust, which may form during storage on the work under acceptable conditions, will not be deemed cause to require cleaning. Thin powdery rust and tight rust is not considered detrimental and need not be removed.

- (a) Reinforcement Bars. Reinforcement bars will be accepted according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Reinforcement Bar and/or Dowel Bar Plant Certification Procedure". The Department will maintain an approved list of producers.
- (1) Reinforcement Bars (Non-Coated). Reinforcement bars shall be according to ASTM A 706 (A 706M), Grade 60 (420) for deformed bars and the following.
 - a. For straight bars furnished in cut lengths and with a well-defined yield point, the yield point shall be determined as the elastic peak load, identified by a halt or arrest of the load indicator before plastic flow is sustained by the bar and dividing it by the nominal cross-sectional area of the bar.
 - b. Tensile strength shall be a minimum of 1.20 times the yield strength.
 - c. For bars straightened from coils or bars bent from fabrication, there shall be no upper limit on yield strength; and for bar designation Nos. 3 - 6 (10 - 19), the elongation after rupture shall be at least 9 percent.
 - d. Heat Numbers. Bundles or bars at the construction site shall be marked or tagged with heat identification numbers of the bar producer.
 - e. Guided Bend Test. Bars may be subject to a guided bend test across two pins which are free to rotate, where the bending force shall be centrally applied with a fixed or rotating pin of a certain diameter as specified in Table 3 of ASTM A 706 (A 706M). The dimensions and clearances of this guided bend test shall be according to ASTM E 190.
 - f. Spiral Reinforcement. Spiral reinforcement shall be deformed or plain bars conforming to the above requirements or cold-drawn steel wire conforming to AASHTO M 32.

- (2) Epoxy Coated Reinforcement Bars. Epoxy coated reinforcement bars shall be according to Article 1006.10(a)(1) and shall be epoxy coated according to AASHTO M 284 (M 284M) and the following.
 - a. Certification. The epoxy coating applicator shall be certified according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Epoxy Coating Plant Certification Procedure". The Department will maintain an approved list.
 - b. Coating Thickness. When spiral reinforcement is coated after fabrication, the thickness of the epoxy coating shall be 7 to 20 mils (0.18 to 0.50 mm).
 - c. Cutting Reinforcement. Reinforcement bars may be sheared or sawn to length after coating, providing the end damage to the coating does not extend more than 0.5 in. (13 mm) back and the cut is patched before any visible rusting appears. Flame cutting will not be permitted.
- (b) Reinforcement Fabric. Reinforcement fabric shall be according to the following.
 - (1) Welded Wire Fabric. Welded wire fabric shall be according to the requirements of AASHTO M 55 or M 221. Welded wire fabric for concrete pavement may be furnished in either flat sheets or hinged sheets. The method of hinging the sheets shall meet the approval of the Engineer.

All welded wire fabric will be accepted according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Reinforcement Fabric Plant Certification Procedure". The Department will maintain an approved list of producers.
 - (2) Bar Mat Fabric. Bar mat fabric shall be according to the requirements of AASHTO M 54 (M 54M). Longitudinal bars shall be Grade 60. The fabric shall be furnished either in flat sheets or hinged flat sheets.
- (c) Prestressing Steel Strand. Prestressing steel strand shall be according to AASHTO M 203.

1006.11 Pavement Longitudinal Metal Joints, Dowel Bars, and Dowel Bar Assemblies. Pavement longitudinal metal joints, dowel bars, and dowel bar assemblies shall be as follows.

- (a) Pavement Longitudinal Metal Joint, Pins and Bar Supports. Longitudinal metal joint for pavement, pins for installing the joint and supports for bars in pavement shall be as specified.
- (b) Dowel Bars. Dowel bars shall be plain, round bars according to the requirements of AASHTO M 227 Grades 70 through 80 (M 227M Grades 485 through 555). The finished bars shall be saw cut and free from burrs or out-of-round ends which will prevent their slipping easily in the concrete. All

dowel bars will be accepted according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Reinforcement Bar and/or Dowel Bar Plant Certification Procedure". The Department will maintain an approved list of producers. The bars shall be epoxy coated according to AASHTO M 284, except patching of the ends will not be required. The epoxy coating applicator shall be certified according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Epoxy Coating Plant Certification Procedure". The Department will maintain an approved list.

- (c) **Dowel Bar Assembly.** The dowel bar assembly shall be an approved welded assembly possessing the rigidity to hold the dowel bars during the placing and compacting of the concrete to the degree of alignment specified. The assembly shall have two parallel spacer bars and two subgrade bearing members. An upright bar support of each end of each dowel bar shall be welded to both the spacer bar and the bearing member at appropriate points to hold the bars at the design height.

The dowel bars shall be spaced as shown on the plans. The alternate ends of dowel bars shall be welded to the spacer bars or the upright bar, without repair to the epoxy. One weld is permitted per dowel bar. The opposite end of each dowel shall be held securely in place by means of wire loops or metal tubes welded to the spacer bar. Suitable ties shall be provided to hold the contraction joint assembly in normal position during shipping, handling and installation. Wire sizes shall be at least W7 for the outside spacer bars, bearing member, and upright supports. The tie wires used for securing the spacer bars shall be at least W3 wires.

The assembly shall be provided with two continuous bearing plates of at least 2 in. (50 mm) width and 0.0359 in. (0.9 mm) thickness sheet steel. The bearing plates shall be attached by welding to the subgrade members or by suitable clips and shall be punched to receive the protruding ends of the upright supports and stakes. The subgrade bearing members may be omitted if suitable subgrade plates are shop welded to the assembly and provide equivalent rigidity. Bearing plates may be omitted on stabilized subbases. The welds in the assembly shall be securely made. A broken weld will be sufficient cause for the rejection of the length or section of the assembly in which it occurs.

1006.12 Steel Forgings. Steel forgings shall be according to AASHTO M 102 and shall be the class specified.

1006.13 Reserved.

1006.14 Gray Iron Castings. Gray iron castings shall be according to AASHTO M 105 and AASHTO M 306, except the tolerance for "Other Dimensions" shall be + 1/4 in. (6 mm). Castings shall be Class 35. Tensile tests will be required and standard test specimens shall be furnished without charge.

The lid or grate of all castings within the area of the pavement or gutter shall fit and have contact with the frame as to ensure the lid or grate from jumping or rattling when struck by vehicles.

All frames within the area of the pavement or gutter having circular lids shall have the bearing surfaces of the lid and frame machined or ground so that there will be no variation from a circular, straight edge, of the dimensions corresponding to the lid bearing surface. The diameter of the lid shall be such as to fit the frame without wedging.

Castings for frames, grates, and lids shall be proof loaded according to AASHTO M 306. Certification of the test results shall be provided to the Engineer.

1006.15 Ductile Iron Castings. Ductile iron castings shall be according to ASTM A 536.

Casting for frames, grates, and lids shall be fabricated of Grade 65-45-12. Castings lying within the area of the pavement or gutter shall meet the same requirements as specified in Article 1006.14 for gray iron castings.

Casting for frames, grates, and lids shall be proof loaded as specified in Article 1006.14.

1006.16 Malleable Castings. Malleable castings shall be according to ASTM A 47 (A 47M), Grade No. 32510.

1006.17 Steel Rods, Turnbuckles, Bolts, Washers, and Other Metal Fastenings for Timber Structures. Steel rods shall be SAE 1020 or other steel meeting the approval of the Engineer. Turnbuckles shall be drop-forged and conform in dimensions and weight (mass) of the latest Manual of the American Institute of Steel Construction. The distance between the heads shall be 6 in. (150 mm). Bolts shall be U.S. Standard. Lag screws and nails shall be standard form. Washers may be cast, malleable, or cut steel.

Rods, turnbuckles, bolts, washers, and other metal fasteners shall be stainless steel according to Article 1006.29(d) or hot-dipped galvanized according to AASHTO M 232, Class C, except the minimum weight (mass) of zinc coating shall be 2.0 oz/sq ft (610 g/sq m).

1006.18 Steel Pipe. Steel pipe shall be of the size and weight (mass) specified and shall be according to ASTM A 53 (A 53M). The pipe shall be black.

1006.19 Cast Iron Water Pipe. Cast iron water pipe shall be according to Federal Specifications WW-P-421 for Pipe; Water, Cast-Iron (Bell and Spigot). The pipe shall be of the size and class specified.

1006.20 Cast Iron Soil Pipe. Cast iron soil pipe and fittings shall be according to Federal Specifications WW-P-401 for Pipe and Pipe-Fittings; Soil, Cast-Iron. The pipe shall be of the grade known commercially as "Extra Heavy".

1006.21 Reserved.

1006.22 Reserved.

1006.23 Steel Posts, Blockouts, Restraints, and Wire Rope for Guardrail.

Steel posts and blockouts shall be according to AASHTO M 270 Grade 36 (M 270M Grade 250). Steel restraints shall be according to AASHTO M 227 Grades 70 through 80 (M 227M Grades 485 through 555). Steel posts and restraints shall be galvanized according to AASHTO M 111. Wire rope for cable assemblies shall be according to AASHTO M 30, Type II, Class A coating.

1006.24 Reserved.

1006.25 Steel Plate Beam Guardrail. Steel plate beam guardrail, including bolts, nuts, and washers, shall be according to AASHTO M 180. The guardrail shall be Class A, with a Type II galvanized coating; except the weight (mass) of the coating for each side of the guardrail shall be at least 2.00 oz/sq ft (610 g/sq m). The coating will be determined for each side of the guardrail using the average of at least three non-destructive test readings taken on that side of the guardrail. The minimum average thickness for each side shall be 3.4 mils (86 µm).

Steel plates for mounting guardrail on existing culverts shall be according to AASHTO M 270 Grade 36 (M 270M Grade 250) and zinc coated according to AASHTO M 232, Class B.

The Department will accept guardrail based on the "Brand Registration and Guarantee" requirements of AASHTO M 180. The Department will maintain an approved list of producers.

In order to prevent rapid oxidation of the zinc coating, all galvanized rail elements, end sections, splice plates, posts, and accessories shall be protected from rain, snow, and other weathering conditions while they are stored prior to installation. This protection shall consist of storing the galvanized parts for the guardrail off the ground surface, so that they will not come in contact with surface run-off water, and properly covering the parts on the top and on all sides. Special care in storing the rail elements, end sections, and splice plates shall be used so that no moisture gets between the pieces when they are stacked in contact with each other.

When using treated wood for blockouts, the fasteners shall be stainless steel according to Article 1006.29(d) or hot-dipped galvanized according to AASHTO M 232, Class C, except the minimum weight (mass) of zinc coating shall be 2.0 oz/sq ft (610 g/sq m).

When erected, the surfaces of the rail elements, end sections, and splice plates shall have a bright finish and shall not be tarnished. If evidence of "white rust" (zinc oxide) is present, and visible pitting of the zinc coating has not occurred, the rail may be cleaned and accepted. If visible pitting of the coating has occurred, the material is unacceptable.

1006.26 Cables and Accessories for Cable Road Guard. Cable and accessories for cable road guard shall be as follows.

- (a) Cables and Fittings. Wire cable and fittings for cable road guard shall be according to AASHTO M 30, Type I, II, or IIa, Class A coating.
- (b) Accessories. Accessories shall be according to the following.

- (1) Rods, Nuts, and Washers. The rods, nuts, and washers shall be according to AASHTO M 314, Grade 36.
- (2) Turnbuckles. The turnbuckles shall be according to ASTM F 1145, Type 1, Grade 1, Class B.
- (3) Steel Plate. Steel plate shall be according to AASHTO M 270, Grade 36.

After fabrication, all accessories shall be galvanized according to AASHTO M 232. The small articles may be zinc-coated by the mechanically deposited process according to AASHTO M 298, Class 50.

1006.27 Chain Link Fence. The various components of chain link fence shall be as follows.

- (a) Fabric. The fabric shall be according to one of the following.
 - (1) The fabric shall be woven in 2 in. (50 mm) mesh with 0.148 in. (3.75 mm) diameter wire meeting one of the following requirements of AASHTO M 181.
 - a. Type I, Class D (zinc-coated steel)
 - b. Type II (aluminum-coated steel)
 - c. Type III (aluminum alloy)
 - d. Type IV, Class B (polyvinyl chloride (PVC)-coated steel). When vinyl-coated fabric is used, the posts, fence framework, gates, tension wire, fabric ties, and fittings shall be vinyl-coated according to the same requirements as the coating of the fabric. All non-aluminum material shall be galvanized prior to vinyl coating.
 - (2) Fabric shall be according to ASTM F 1345, woven in 2 in. (50 mm) mesh with 0.148 in. (3.75 mm) diameter wire protected by Class 2 mischmetal coating. The weight of Zn - 5A1 - MM alloy coating shall be at least 1.0 oz/sq ft (305 g/sq m) of uncoated wire surface.
- (b) Metal Posts. Metal posts, rail, braces, and gate frames shall be the shape and dimension as shown on the plans and shall meet the bending strength and dimension tolerance of AASHTO M 181.

Pipe and rolled shapes shall be according to ASTM F 1043. Square hollow structural steel tubing shall be according to ASTM A 500 Grade B or ASTM A 501, with ASTM F 1043, Type A internal and external coating.

- (c) Tension Wire. Tension wire shall be according to AASHTO M 181, Type I, Class 2, or Type II.

- (d) Fabric Ties. The fabric ties to be used with other than vinyl-coated fabric shall be stainless steel hog rings [minimum diameter of 0.120 in. (3 mm)], 9 gauge aluminum wire or 9 gauge galvanized steel wire with 1.2 oz/sq ft (370 g/sq m) zinc coating. The fabric ties to be used with vinyl fabric shall be of the same material as the fabric.
- (e) Fittings. All miscellaneous fittings shall be made of malleable cast iron or pressed steel and shall be galvanized according to AASHTO M 232.
- (f) Bolts and Nuts. All bolts and nuts shall be according to ASTM A 307 and shall be zinc-coated according to AASHTO M 232 or AASHTO M 298, Class 50 with galvanizing not to exceed 6 mils (150 µm).

1006.28 Woven Wire Fence. The various components of woven wire fence shall be as follows.

- (a) Woven Wire Fencing. Woven wire fencing shall be according to AASHTO M 279. The Design Number of the fence fabric shall be either 939-6-11, Grade 60 or 939-6-12 1/2, Grade 125. The metallic coating shall be either Type A or Type Z, Class 3.
- (b) Barbed Wire. Barbed wire shall be according to AASHTO M 280, Design Number 12-4-5-14R. The metallic coating shall be either Type A or Type Z, Class 3. The wire shall consist of two strands of 12 1/2 gauge wire with four point barbs of 14 gauge wire spaced 5 in. (125 mm) apart. Galvanized barbed wire shall be according to the Specifications for zinc coated (galvanized) steel barbed wire, AASHTO M 280, Class 3 with a minimum coating of 0.80 oz/sq ft (245 g/sq m) of wire surface. Aluminum coated steel barbed wire shall be according to the Specifications for galvanized steel barbed wire, except the wire shall be aluminum coated. The wire shall have at least a 0.25 oz (76 g) coating of aluminum alloy per square foot (square meter) of uncoated surface.
- (c) Brace Wires. Brace wires shall be zinc coated (galvanized) or aluminum coated No. 9 gauge steel wire according to the Specifications for zinc coated (galvanized) steel or aluminum coated fencing.
- (d) Metal Posts. Metal posts shall be the shapes and dimensions shown on the plans. Line posts shall include a firmly attached, tapered anchor plate having an area of at least 18 sq in. (12,000 sq mm). The anchor plate shall be fabricated from minimum 12 gauge thickness steel. Steel pipe for metal posts shall be steel pipe, Type A, Type B, or Type C according to Article 1006.27. Structural shapes for posts shall be fabricated from steel according to the requirements of AASHTO M 281, Grades A or B. All structural shapes shall be galvanized according to AASHTO M 111 using zinc of any grade according to the requirements of AASHTO M 120. The zinc coating shall be at least 2.0 oz/sq ft (610 g/sq m) of surface.

Square hollow structural tubing shall be according to ASTM A 500, Grade B or ASTM A 501. The tubing shall be galvanized inside and outside according to AASHTO M 111, using zinc of any grade according to the

requirements of AASHTO M 120. The coating shall be at least 2.0 oz/sq ft (610 g/sq m) of surface.

- (e) Metal Braces. Metal braces shall have the shapes and dimensions shown on the plans. They shall be according to the Specifications for metal posts, either steel pipe or structural shapes, and shall be galvanized as specified for the metal posts.
- (f) Gate Frames. Gate frames shall consist of galvanized steel pipe having the dimensions shown on the plans and according to the specifications for steel pipe line posts.
- (g) Miscellaneous Materials. Miscellaneous materials such as, but not limited to, wire, clips, or other metal devices for fastening the barbed wire and fencing to the posts, shall be of good commercial quality and galvanized. Staples shall be at least 1 1/2 in. (38 mm) long of No. 9 galvanized wire.
- (h) Post Tops. Steel pipe and steel tubing posts shall be furnished with steel or malleable iron or wrought iron post tops of approved type, and shall be galvanized according to AASHTO M 232.

1006.29 Metal Posts and Hardware for Highway Markers, Signs, and Delineators. Metal posts for highway markers, signs, and delineators shall be according to the following, except that delineator posts shall be unfinished steel.

- (a) Post Materials.
 - (1) Steel. The steel used in the posts shall be hot rolled according to the physical properties of ASTM A 499, Grade 60 and to the chemical properties of ASTM A 1 for 91 lb (41 kg) or for larger steel rails.
 - (2) Aluminum. The aluminum used in the posts shall be according to the requirements of ASTM B 221 (B 221M), Alloy 6061-T6, which shall meet the following minimum requirements.

Tensile Strength	38,000 psi (260,000 kPa)
Yield Point	35,000 psi (240,000 kPa)
Elongation 2 in. (50 mm)	10 percent

- (b) Fabrication and Finish.
 - (1) Weight (Mass). The average weight (mass) of the posts per foot (meter) of length shall be not less than the following.

Type of Post	Aluminum lb/ft (kg/m)	Steel lb/ft (kg/m)
A	0.90 (1.3)	2.00 (3.0)
B	1.30 (1.9)	3.00 (4.5)
C	---	1.12 (1.7)

Individual posts shall not vary more than ten percent below their average weight.

- (2) **Punching.** In the case of steel posts, all punching or drilling shall be done prior to galvanizing.
- (3) **Galvanized Steel Posts.** Steel posts shall be galvanized by the hot-dip process according to AASHTO M 111.
- (4) **Enameled Steel Posts.** Steel posts shall be painted with a weather resistant, rust inhibitive, high quality, dark green enamel which shall produce a hard mar resistant coating, free from paint cracks, blisters, or other defects. The quality of the paint shall be such that when the finished post is struck a light blow with a sharp tool, the paint shall not crack or chip, and if scratched with a knife, shall not powder. The thickness of the dry film enamel shall be a minimum of 1 mil (25 μ m). It shall pass the standard 100 hour salt spray test [20 percent solution by spray of fog 70 °F (21 °C)]. Painting shall be the final process after all fabrication and punching has been completed.

The enamel for steel posts shall have the following properties.

Solids by Mass (Minimum)	54.6%
Mass lb/gal (kg/L) (Minimum)	8.6 (1)
Viscosity at 77 °F (25 °C), No. 4 Ford	45-50 sec
60% Gloss	High
Method of Application	Flow Coat
Cure Schedule 300 °F (150 °C)	20 minutes

- (5) **Polyester Coated Steel Posts.** Steel posts shall be coated with an electrostatically applied powder coating of a dark green, pigmented, urethane-cured, polyester having the following properties.

Polyester Resin (Molecular weight equivalent 2,000-5,000)	40-75%
Blocked Isocyanate Curing Agent (Molecular weight equivalent 1,000-3,000)	10-25%
Flow Control Agent (Acrylo-terpolymers)	0.1-2.0%
Exterior Durable Grade Pigment and Extender	25-50%
Organic Volatile Content (Maximum).....	3%

The posts shall be cleaned free of oil, loose mill scale, and rust by pickling or by blast cleaning to near white with a blast profile not greater than 2 mils (50 μ m). They shall then be pretreated with 40 to 70 mg/sq ft (430 to 750 mg/sq m) of iron phosphate and chemically sealed.

The coating shall be applied immediately after cleaning as an electrostatically charged dry powder sprayed onto the grounded post using an electrostatic spray gun. The thickness of the applied coating

shall be a minimum of 2.5 mils (63 μm) measured on a flat surface of the post according to ASTM D 1186.

All systems for handling the coated posts shall have padded contact areas. All bundling bands shall be padded or suitable banding shall be used to prevent damage to the coating. The posts or bundles shall not be dropped or dragged. The bundled posts shall be transported with care and stored above the ground on wooden or padded supports.

- (6) Workmanship and Finish. The posts shall be symmetrical and well formed. They shall be free from injurious defects which will impair their strength or appearance. The zinc coating on the steel posts shall be free from such imperfections as lumps, blisters, uncoated spots, dross, and flux.
- (c) Tests.
- (1) Tension Tests. The tensile properties of the metals shall be determined by the method outlined in AASHTO T 68.
 - (2) Tests for Weight of Zinc Coating. The weight of the zinc coating shall be determined by the method outlined in AASHTO M 111. As an option, the weight of the coating may be determined by weighing one or more full size specimens after pickling and drying and again after coating.
 - (3) Tests for Polyester Coating. The coated posts shall be capable of meeting the following requirements.
 - (a) Impact. The coating shall show no cracks or breaks when subjected to an impact of 100 in. lb (11 J) according to ASTM D 2794.
 - (b) Salt Spray. When tested for 500 hours according to ASTM B 117, no rust, blisters, or undercutting of uncoated or scribed areas will be apparent.
 - (c) Humidity. There shall be no blistering of the coating or gloss loss greater than five percent when tested according to ASTM D 2247.
 - (d) Weathering. There shall be no more than 15 percent loss of gloss and no appreciable color change when tested for 1,000 hours in a carbon arc weatherometer according to ASTM G 23-96, Type EH.
 - (4) Certification. When steel posts are supplied, the Contractor shall furnish a certification from the manufacturer that the posts meet the specified chemical and physical properties. The Department reserves the right to test samples for these and other requirements of these Specifications.
- (d) Hardware. Hardware for attaching sign panels to posts and other applications shall be zinc coated steel or stainless steel.

Steel bolts, nuts, and washers shall be according to ASTM A 307. They shall be zinc-coated according to AASHTO M 232, AASHTO M 298, Class 50, or ASTM B 633 (B 633M) SC 3.

Stainless steel bolts shall be according to ASTM F 593 Alloy Group 1, conditions F593C or F593B; or ASTM A 193 (A 193M), Class 1 Grade B8 or Class 1A Grade B8A, or Class 2 Grade B8. Stainless steel nuts shall be according to ASTM F 594 Alloy Group 1, Conditions CW1 (F594C), SH3 (F594C), or SH4 (F594D); ASTM A 194 (A 194M) Grade 8, 8M, or 8F with a UNC Series Class 2B fit. Stainless steel washers shall be plain flat, Type 304 or 316, according to Federal Specification FF-W-92. Nuts shall have a hardness greater than that of the bolt to prevent thread stripping. Thread overload shall be prevented by use of torque control, which is dependent on bolt diameter and specific hardness.

1006.30 Aluminum for Railings. Aluminum for railings shall be as follows.

- (a) **Cast Aluminum Railing Posts.** Cast aluminum railing posts shall be according to ASTM B 108, Alloy A444.0-T4 for permanent mold castings; ASTM B 26, Alloy 520.0-T4 for sand castings; or ASTM B 618, Alloy 520.0-T4 for investment castings. All castings shall have a radiographic discontinuity level according to Grade C, 1/4 in. (6 mm) section thickness.
- (b) **Aluminum Alloy Extruded Rail.** Aluminum alloy extruded rail shall be according to ASTM B 221 (B 221M), Alloy 6061-T6 with a minimum yield of 35,000 psi (240,000 kPa), a minimum tensile strength of 38,000 psi (262,000 kPa), and an elongation of ten percent in 2 in. (50 mm).

1006.31 Stainless Steel Hardware. Stainless steel hardware shall be as follows.

- (a) **Stainless Steel Machine Bolts or Cap Screws.** Stainless steel nuts, washers, lock washers, machine bolts, or cap screws shall be according to the requirements of Article 1006.29(d).
- (b) **Stainless Steel Bars.** Stainless steel bars shall be according to the requirements of ASTM A 276, Type No. 302 or 304, Condition B. Threads, when required, shall be Class 2B.

1006.32 Stud Shear Connectors. Stud shear connectors shall be according to the requirements of AASHTO M 169 cold drawn bars, Grades 1015, 1018, or 1020, either semi- or fully-killed. Welding and workmanship shall be according to the requirements of the BWC.

1006.33 Seamless Copper Water Tube. Seamless copper water tube shall be according to the requirements of ASTM B 88 (B 88M), Type K, except that the tolerance for wall thickness and weight/foot (mass/meter) shall be increased by 50 percent.

1006.34 Galvanized Steel for Railings. Galvanized steel for railing shall be according to the following.

- (a) Steel Posts for Railings. Steel posts shall be according to the requirements of AASHTO M 270, Grade 50, and shall be galvanized according to AASHTO M 111.
- (b) Tubular Steel Rail for Railings. Tubular steel rail shall be according to the requirements of ASTM A 500, Grade B, and shall be galvanized according to AASHTO M 111.

Tubular steel from all heats supplied shall be tested for impact toughness according to AASHTO T 266, "Charpy V-Notch (CVN) Impact Testing of Metallic Materials". The CVN impact requirements shall be 15 ft lb (20 J) at 0 °F (-18 °C). For each heat supplied, the manufacturer shall furnish one 24 in. (600 mm) specimen, marked with its heat number, for impact testing.

In lieu of the above, the manufacturer may choose to supply tubing that has been tested for toughness according to ASTM E 436, "Standard Method for Drop-Weight Tear Tests of Ferritic Steels", as modified herein. Tubing test samples shall be taken and tested prior to delivery of the railing to the Contractor. The taking of the test samples shall be witnessed, and the testing shall be performed, by an approved independent testing laboratory.

Drop-weight tear testing shall be done on test specimens obtained from galvanized tubing with the same heat number as that being used. Testing shall be conducted at a temperature of 0 °F on 2 x 9 in. (-18 °C on 50 x 225 mm) specimens supported to provide a 7 in. (175 mm) clear span. Galvanizing shall not be removed from the specimens. Three 2 x 9 in. (50 x 225 mm) test specimens shall be cut from each of the unwelded sides for a total of nine specimens.

The three specimens from the side with the lowest average shear area shall be disregarded when calculating the final average shear area. The final average shear area shall then be calculated using the six remaining specimens. If the average shear area falls below 50 percent, material from the heat represented by these tests shall be rejected, except that if the average shear area is 30 percent or greater, one retest at a sampling frequency three times that of the first test, and with no samples excluded in calculating the average, will be permitted. Material not having a 50 percent average shear area upon retest shall be rejected. Certified test data shall be submitted with each shipment of railing.

No transverse welds will be permitted in the rail section.

The manufacturer of the tubing shall, before galvanizing, identify the product with the steel heat number (or with some number that is traceable to the heat number) and a unique manufacturer's identification code. The identification method shall be such that identification shall be on only one face of the section, be repeated at intervals no greater than 4 ft (1.2 m), and not extend into the curved surface of the tubing at the corners.

- (c) Steel Shapes and Plates for Railing. Steel angles shall be according to the requirements of AASHTO M 270, Grade 50 (M 270M, Grade 345), and all other steel shapes and plates shall be according to the requirements of AASHTO M 270 Grade 36 (M 270M, Grade 250). This material shall be galvanized according to AASHTO M 111.
- (d) Storing on Site. In order to prevent rapid oxidation of the zinc coating, the Contractor shall protect all galvanized rail elements, splice sections, posts, and accessories from rain, snow, and other weathering conditions while they are stored on the site prior to installation. This protection shall consist of storing the galvanized parts of the railing off the ground surface so that they will not come in contact with surface run-off water and properly covering the parts on the top and all sides. The Contractor shall use special care in storing this material so that no moisture gets between the pieces when they are stacked in contact with each other. When erected, the surfaces of the rail elements and posts shall have a uniform finish and shall not be tarnished, have mottled areas or a gritty appearance, nor show dip marks or brush marks. If "white rust" (zinc oxide) has formed on any of the surfaces of the rail elements, the affected material shall be rejected by the Engineer.

1006.35 Gabions and Slope Mattresses. The material shall be according to the following.

- (a) Fabric. The baskets shall be constructed of galvanized, aluminized, or PVC-coated galvanized or aluminized steel wire.
 - (1) Gabion baskets shall be constructed of one of the following two types.
 - a. Hexagonal mesh fabric with at least three half twists. The fabric opening shall have nominal dimensions of 3.25 x 4.50 in. (82 x 115 mm).
 - b. Welded wire fabric with a minimum average weld shear value of 584 lb (2600 N) with no value less than 450 lb (2000 N). The fabric opening shall have nominal dimensions of 3.00 x 3.00 in. (75 x 75 mm).
 - (2) Slope mattress baskets shall be constructed of one of the following two types.
 - a. Hexagonal mesh fabric with at least three half twists. The fabric opening shall have nominal dimensions of 2.50 x 3.25 in. (60 x 82 mm).
 - b. Welded wire fabric with a minimum average weld shear value of 290 lb (1300 N) with no value less than 225 lb (1000 N). The fabric opening shall have nominal dimensions of 1.50 x 3.00 in. (38 x 75 mm).
- (b) Wires for Selvedges, Lacing, and Internal Connections. All wires shall be of the same material and coating finish as the fabric.

- (c) Galvanized Steel Wire. The wire shall be according to ASTM A 641 (A 641M), Class 3, Soft.
- (d) Aluminized Steel Wire. The wire shall be according to ASTM A 809, Soft.
- (e) PVC-Coated Galvanized or Aluminized Steel Wire. The PVC coating shall be applied to wire according to ASTM A 641 (A 641M), Class 3, Soft, or ASTM A 809, Soft. The PVC shall be extruded and adhered (bonded), shall be according to ASTM D 2287 and shall be 0.020 in. \pm 0.005 in. (0.500 mm \pm 0.125 mm). The color of the PVC material shall be gray. The PVC coating shall be self-extinguishing and shall not support combustion when subject to the horizontal flame test of ASTM A 470.
- (f) Wire Diameter. The minimum diameter of wires after coating for gabions and slope mattresses shall be according to the following tables.

GABIONS		
	Aluminized and Galvanized	PVC
Fabric Wire	0.118 in. (3.0 mm)	0.136 in. (3.5 mm)
Selvedge Wire ^{1/}	0.150 in. (3.8 mm)	0.163 in. (4.1 mm)
Lacing and Internal Connecting Wires	0.087 in. (2.2 mm)	0.117 in. (3.0 mm)

SLOPE MATTRESSES		
	Aluminized and Galvanized	PVC
Fabric Wire	0.087 in. (2.2 mm)	0.117 in. (3.0 mm)
Selvedge Wire ^{1/}	0.106 in. (2.7 mm)	0.136 in. (3.5 mm)
Lacing and Internal Connecting Wires	0.087 in. (2.2 mm)	0.117 in. (3.0 mm)

1/ Does not apply to welded wire fabric.

1006.36 Wire Fasteners. Wire fasteners shall be made of galvanized steel wire, aluminized steel wire, or stainless steel wire. Galvanized wire fasteners shall be used on galvanized baskets, aluminized wire fasteners shall be used on aluminized baskets, and stainless steel wire fasteners shall be used on PVC coated baskets. Wire fasteners shall resist a force of at least 600 lb (2700 N) while remaining in a closed position when subjected to a directional tension force along any axis of the fastener.

- (a) Galvanized Steel Wire. Coating requirements shall be according to ASTM A 764, Type 3.
- (b) Aluminized Steel Wire. Coating requirements shall be according to ASTM A 809.
- (c) Stainless Steel Wire. The wire shall be according to ASTM A 313, 302 grade.

SECTION 1007. TIMBER AND PRESERVATIVE TREATMENT

1007.01 Description. This Specification covers structural timber for bridges and guardrail, sign posts, timber piling, guard and guide posts, bracing stakes, woven wire fence posts and braces, and preservative treatment.

Inspection of both treated and untreated products shall be according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Inspection Procedures and Approved Inspection Agencies for Timber and Preservative-Treated Timber Products".

1007.02 Definition of Terms. The terms used shall be interpreted according to ASTM D 9.

1007.03 Structural Timber. Structural timber shall be either southern pine or Douglas fir (coast region).

- (a) Treated and Untreated Timber. When treated material is specified, the method of treatment shall be according to Article 1007.12. There shall be no heartwood requirements for timber which is to receive a preservative treatment and the amount of sapwood shall not be limited. All timber to be used without preservative treatment shall contain not less than 85 percent of heartwood measured on the girth.
- (b) Standard Sizes and Grading Requirements. Rough cut and surfaced timber shall meet the applicable requirements for size and grading according to ASTM D 245 and the Southern Pine Inspection Bureau, or the West Coast Lumber Inspection Bureau, except as provided herein.

All pieces shall be cut to length with square ends.

The dimensions and surfacing requirements will be shown in the contract.

- (c) Strength Requirements. The design strengths for structural timber shall be as shown on the plans, and according to the Southern Pine Inspection Bureau or the West Coast Lumber Inspection Bureau.

1007.04 Reserved.

1007.05 Sign Posts. Sign posts shall be either southern pine or Douglas fir and shall be according to the following.

- (a) Southern pine shall be No. 2 according to the Southern Pine Inspection Bureau Grading Rules and the following.
 - (1) Paragraph 313 for Structural Light Framing shall be used for 4 X 4 in. (100 X 100 mm) posts.
 - (2) Paragraph 313 for Structural Joists and Planks shall be used for 4 X 6 in. (100 X 150 mm) posts.

- (b) Douglas fir shall be No. 2 according to the West Coast Lumber Inspection Bureau Standard Grading Rules and the following.
 - (1) Paragraph 124C for Structural Light Framing shall be used for 4 X 4 in. (100 X 100 mm) posts.
 - (2) Paragraph 123C for Structural Joists and Planks shall be used for 4 X 6 in. (100 X 150 mm) posts.

The size and length of posts shall be as shown on the plans. The dimensions for the posts are nominal. The surfacing shall be S4S (all four sides).

1007.06 Steel Plate Beam Guardrail and Wood Guardrail. The posts, rails, and other timber shall be according to the Southern Pine Inspection Bureau or the West Coast Lumber Inspection Bureau. The size and surfacing requirements will be shown in the contract.

1007.07 Cable Road Guard. The posts and other timber for cable road guard shall be according to the Southern Pine Inspection Bureau or the West Coast Lumber Inspection Bureau. The size will be as shown on the plans. The surfacing shall be S4S or rough sawn.

1007.08 Piling. Timber piling shall be treated or untreated.

- (a) Untreated Timber Piling. When untreated timber piles are specified, they shall be any of the following species of woods which will satisfactorily withstand driving.

Cedar, Northern White	Pine, Southern
Cedar, Western Red	Pine, Norway
Chestnut	Cypress
Elm, Rock	Fir, Douglas (coast region)
Hickory	Oak

- (b) Treated Timber Piling. When treated timber piles are specified, they shall be one of the following types of wood.

Pine, Southern
Fir, Douglas (coast region)
Oak, Red (commercial)

The method of treatment shall be according to Article 1007.12.

- (c) Quality. All timber piles shall be cut from sound and solid trees. To avoid deterioration, they shall be cut within 12 months prior to use. The butt and tip shall be cut square with the axis of the pile. Piles shall be cut above the ground swell and shall taper from butt to tip. All knots and limbs shall be trimmed or cut flush with the surface of the pile.

The piles shall contain no unsound knots or knots in groups. Sound knots will be permitted, provided the diameter of the knot does not exceed 4 in.

(100 mm) or 1/3 of the diameter of the pile at the point where it occurs. The piles shall be free from twist of grain exceeding 1/2 the circumference in any 20 ft (6 m) of length; shake more than 1/3 the diameter of the pile, or shake appearing on both ends of the pile; rot, incipient, or advanced decay; and season checks which penetrate more than 1/4 of the diameter of the pile or are more than 1/4 in. (6 mm) in width. Any defect or combination of defects, which will impair the strength of the pile more than the maximum knot, will not be permitted.

Untreated piles shall have all the outer bark removed. Piles to be treated shall be peeled by removing all the outer bark and at least 80 percent of the inner bark. No strip of inner bark remaining on the piles shall be over 3/4 in. (20 mm) wide and there shall be at least 1 in. (25 mm) of clean wood surface between any two such strips.

A line drawn from the center of the tip to the center of the butt shall not fall outside the center of the pile at any point more than one percent of the length of the pile. In short bends, the distance from the center of the pile to a line stretched from the center of the pile above the bend to the center of the pile below the bend shall not exceed four percent of the length of the bend, or 2 1/2 in. (63 mm). Piles shall be free from reverse bends.

- (d) Dimensions. All measurements shall be made under the bark. Tip and butt measurements shall be as listed in the following table.

Length of Pile	Diameter - (in.)		
	Tip Minimum	36 in. from Butt Minimum	Butt Maximum
Less than 20 ft	8	11	20
20 and less than 40 ft	8	12	20
40 and less than 60 ft	7	13	20
60 ft and more	6	13	20

Length of Pile	Diameter - (mm)		
	Tip Minimum	900 mm from Butt Minimum	Butt Maximum
Less than 6 m	200	275	500
6 m and less than 12 m	200	300	500
12 m and less than 18 m	175	325	500
18 m and more	150	325	500

1007.09 Guard Posts and Guide Posts. The posts shall be of southern pine, Douglas fir, northern white cedar, redwood, green and white ash, American and slippery elm, black gum, or red oak.

- (a) Dimensions. The dimensions of the posts will be shown in the contract.
- (b) Quality. The posts shall be cut from sound and solid trees. They shall contain no unsound knots. Sound knots will be permitted, provided the diameter of the knot does not exceed 1/3 the diameter of the post at the point where it occurs. They shall be free from excess twist of grain; ring

shake more than 1/3 the diameter of the post; and rot, incipient or advanced decay, except that in northern white cedar, one pipe rot in the top of the post, and butt rot not to exceed five percent of the area of the butt will be permitted. Season checks which penetrate more than 1/4 the diameter of the posts at the point measured or which are more than 1/4 in. (6 mm) in width will not be permitted. The post shall be free from short or reverse bends. One way sweep or crook will be permitted, provided it does not exceed 2 in. (50 mm) measured at its maximum deviation.

1007.10 Bracing Stakes. Stakes for bracing trees and shrubs shall be of any species of wood which are durable and of sufficient strength to satisfactorily withstand driving.

- (a) Dimensions. For round stakes, the tip diameter shall be not less than 1 3/4 in. (45 mm) nor more than 2 1/2 in. (63 mm), and the butt diameter shall not exceed 3 in. (75 mm). Sawed stakes shall be not less than 1 3/4 in. (45 mm) nor more than 2 in. (50 mm) in width and thickness. The stakes shall be 8 ft (2.4 m) in length; a variation of 2 in. (50 mm) will be permitted.
- (b) Quality. The stakes shall be cut from sound timber. They shall contain no decayed knots, except that small pith knots will be permitted. The diameter of sound knots shall not exceed 1/2 the diameter of the stake at the point where they occur. They shall be free from excess twist of grain, excessive ring shake, and rot, except that in round stakes, pipe rot in the tip of the stakes which does not exceed 1/2 in. (13 mm) in diameter, and butt rot which does not exceed five percent of the area of the butt will be permitted. Season checks shall not penetrate more than 1/4 the diameter of the stake. The stakes shall be free from short or reverse bends. One way sweep or crook will be permitted provided it does not exceed 3 in. (75 mm) measured at its maximum deviation. No more than ten percent of the number of stakes in any lot shall contain the maximum crook or butt rot. The stakes shall be peeled of all outer bark, and all knots and branches shall be cut flush with the surface. The stakes shall be sharpened for driving and the opposite ends cut square.

1007.11 Woven Wire Fence Posts and Braces. The posts and braces shall be of southern pine or Douglas fir.

- (a) Dimensions. The dimensions of the posts and braces will be as shown in the contract. They may be either round or rectangular and if rectangular, they may be rough sawn or surfaced to standard dimensions.
- (b) Quality. The posts and braces shall have all the bark removed; knots and projections trimmed flush with the surface; and shall be sound and free from decay, excessive twist of grain, unsound knots or knots in groups, or any structural defects. Knots in the posts shall not exceed 1 1/2 in. (38 mm) in size.

1007.12 Preservative Treatment. Preservative treatment shall be according to AASHTO M 133, except Copper Azole (CA-B and CBA-A) and ACQ (Type B, C, and D) shall not be used for sign posts.

All fasteners used with treated wood products shall be stainless steel according to Article 1006.29(d) or hot-dipped galvanized according to AASHTO M 232, Class C, except the minimum weight (mass) of zinc coating shall be 2.0 oz/sq ft (610 g/sq m).

1007.13 Handling and Storage. Handling and storage of lumber items shall be as specified in AWP Standard M4.

Treated material shall be placed in a position as to facilitate thorough drainage of any preservative remaining on the material. AWP Standard M4 shall be used for repair of cuts and abrasions and treatment of bored holes. Three brush coats of the repair material shall be used. Each coat shall be allowed to dry before the next coat is applied. Treated material which is otherwise satisfactory may be rejected if coated with dirt. When material is stored for an extended length of time, the material shall be protected from the weather.

SECTION 1008. STRUCTURAL STEEL COATINGS

1008.01 Sampling, Testing, Acceptance, and Certification. Structural steel coatings shall be on the Department's approved list and be according to the following.

- (a) **Qualification Samples and Tests.** The manufacturer shall supply to an independent test laboratory and to the Department, duplicate samples of the structural steel coating for evaluation. Prior to approval and use, the manufacturer shall submit a notarized certification of the independent laboratory, together with results of all tests, stating that this material meets the requirements as set forth herein. The certified test report shall state the lot tested, manufacturer's name, product name, and date of manufacture. New certified tests results and samples for testing by the Department shall be submitted anytime the manufacturing process or paint formulation is changed. All costs of testing (other than tests conducted by the Department) shall be borne by the manufacturer.
- (b) **Acceptance Samples and Certification.** A 1 qt (1 L) sample of each lot of paint produced for use on State or local agency projects shall be submitted to the Department for testing, together with a manufacturer's certification. The certification shall state that the formulation for the lot represented is essentially identical to that used for qualification testing. All acceptance samples shall be taken by a representative of the Department. The structural steel coating shall not be used until tests are completed and they have met the requirements as set forth herein.
- (c) **Packaging and Labeling.** Each container shall have a label clearly showing the manufacturer, product name, lot number, date of manufacture, and shelf life. The label shall also include complete instructions for use of the product. The container shall be coated, if necessary, to prevent attack by the paint components.

1008.02 Inorganic Zinc-Rich Primer. Inorganic zinc-rich primer is a solvent-based, multiple component, self curing alkyl silicate zinc-rich paint which cures

without use of a separate curing solution and is for use only on blast-cleaned steel. The primer shall be applied by spray with only limited application by brush.

The inorganic zinc-rich primer shall be according to AASHTO M 300 Type I. The Volatile Organic Compounds (VOC) shall not exceed 2.8 lb/gal (340 g/L) for both shop and field painting as applied when tested according to ASTM D 3960.

1008.03 Aluminum Epoxy Mastic. Aluminum epoxy mastic shall be a two component epoxy primer containing aluminum pigment designed as a one coat high-build complete protective coating system with excellent adhesion to rusted steel, inorganic zinc, and old paint after such surfaces have been properly cleaned. The aluminum epoxy mastic shall be compatible with a wide range of topcoats including waterborne acrylics, alkyds, and polyurethanes.

The aluminum epoxy mastic shall be according to the following.

- (a) Pigment. The primary pigment shall be either a leafing or non-leafing aluminum pigment. Secondary pigmentation shall not contain more than trace amounts of lead, chromium, or other toxic heavy metals.
- (b) Vehicle. The vehicle shall be a modified epoxy and curing agent which is suitably insensitive to moisture to allow trouble free application.
- (c) Packaged Components. The epoxy coating shall be supplied as a two-component material. It shall be well ground, free of caking, skins, gelation, and excessive setting. The shelf life of each component shall not be less than 12 months.
- (d) Properties of Aluminum Epoxy Mastic. The properties shall be according to the following.
 - (1) The mixed epoxy shall contain a minimum of 87 percent solids by weight, when tested according to ASTM D 1644, Method A, except that the sample shall be heated for 72 hours at 100 ± 2 °F (37.8 ± 1 °C).
 - (2) The unit weight of the unmixed components shall not vary more than ± 0.2 lb/gal (± 24 g/L) from the weight of the original qualification samples.
 - (3) The viscosity of the coating shall be a minimum of 85 KU at 77 ± 2 °F (25 ± 1 °C). Viscosity must be checked immediately after addition and mixing of components.
 - (4) The pot life of the epoxy coating shall be no shorter than two hours at 75 °F (24 °C) or one hour at 90 °F (32 °C).
 - (5) The epoxy coating shall air cure at a temperature of 75 °F (24 °C) or above to a hard tough film within five days, by evaporation of solvent and chemical reaction. It shall be dry to the touch in 24 hours at 75 °F (24 °C), and able to receive foot traffic in 48 hours at 75 °F (24 °C).

- (6) The mixture, when thinned per manufacturer's recommendations, shall exhibit no runs or sags, when applied by conventional or airless spray to produce dry film thicknesses of 5 to 7 mil (125 to 175 micron).
- (7) The Volatile Organic Compounds (VOC) shall not exceed 2.8 lb/gal (340 g/L) as applied when tested according to ASTM D 3960.
- (e) Resistance Tests of Cured Aluminum Epoxy Mastic. The aluminum epoxy mastic shall be tested according to the current Bureau of Materials and Physical Research Illinois Test Procedure, "Resistance Tests of Cured Aluminum Epoxy Mastic". The material will not be accepted if any individual test panel fails any one of the following tests.
 - (1) Fresh Water Resistance. The panels shall show no rusting, blistering, or softening beyond 1/16 in. (1.6 mm) from the scribe mark, when examined after 30 days. Discoloration of the coating will be allowed.
 - (2) Salt Water Resistance. The panels shall show no rusting, blistering, or softening beyond 1/16 in. (1.6 mm) from the scribe mark upon examination after 7, 14, and 30 days. Discoloration of the coating will be allowed.
 - (3) Salt Fog Resistance. After 1,000 hours of continuous exposure, the coating shall show no loss of bond, nor shall it show rusting or blistering beyond 1/16 in. (1.6 mm) from the center of the scribed mark.
 - (4) Weathering Resistance. After 1,000 hours, the panels shall show no loss of bond, nor shall they show rusting, softening, or blistering.

1008.04 Waterborne Acrylic. The acrylic primer and finish coat shall be a two-coat, waterborne acrylic paint system for direct to metal application on prepared structural steel and for topcoating previously painted surfaces. The acrylic primer shall be suitable as an intermediate coat over inorganic and organic zinc primers, aluminum epoxy mastics, acrylics, vinyls, and alkyds. The acrylic finish coat shall be compatible as a topcoat over the primer.

The waterborne acrylic paint system shall be according to the following.

- (a) The acrylic paints shall meet the requirements of the Steel Structures Painting Council's Painting System Specification No. 24.00 (Latex Painting System for Industrial and Marine Atmospheres, Performance-Based) as outlined in Volume 2, Systems and Specifications, Seventh Edition. The performance testing shall comply with Level I, except that Section 6.3, Early Rust Resistance of System shall be modified according to the current Bureau of Materials and Physical Research Illinois Test Procedure, "Modification of Early Rust Resistance of Waterborne Acrylic Paint System".
- (b) Workability. The paints shall be easily applied by conventional and airless spray to smooth vertical surfaces at a minimum dry film thickness of 3 mils (75 microns) per coat without runs, sags, or other film defects. When application is made by brush or roller, multiple coats will be permitted to achieve 3 mils (75 microns) dry film thickness and uniformity of appearance.

- (c) Toxicity. The paints shall not contain more than trace amounts of lead, hexavalent chromium, cadmium, mercury, or other toxic heavy metals.
- (d) Flash Point. The flash point of the coatings shall be greater than 149 °F (65 °C) as determined by a Pensky-Martens Closed Cup Tester according to ASTM D 93.
- (e) Shelf Life. The paints shall show no curdling, gelling, gassing, or an increase in viscosity of more than 10 KU after one year from the date of manufacture when packaged in tightly covered unopened containers and stored at temperatures between 50 and 90 °F (10 and 32 °C).
- (f) Volume Solids. The coatings shall not be less than 32 percent solids by volume.
- (g) Odor. Freshly opened containers of the paints shall not exhibit any rancid, putrid, or other objectionable odors.
- (h) Drying Time. The paints shall set to touch within four hours and dry through within 24 hours when applied at 10 mils (250 microns) wet film thickness and tested according to ASTM D 1640.
- (i) Color and Hiding Power. The color shall be tested according to the current Bureau of Materials and Physical Research Illinois Test Procedure, "Color Difference of Waterborne Acrylic Paint". The primer shall match Munsell Matte or Glossy Color 5Y 8/4 Yellow. The finish coat shall match Munsell Glossy Color 7.5G 4/8 Interstate Green, 2.5YR 3/4 Reddish Brown, 10B 3/6 Blue, or 5B 7/1 Gray. The color difference shall not exceed 10 Hunter Delta E Units for the primer and 3.0 Hunter Delta E Units for the finish coats.

The contrast ratio of the finish coats at 2 mils (50 microns) dry film thickness shall not be less than 0.99 when tested according to ASTM D 2805.
- (j) Gloss. The 60 degrees specular gloss of the finish coats shall not be less than 65 when measured according to ASTM D 523.
- (k) Color and Gloss Retention of Finish Coats. The color and gloss retention shall be tested according to the current Bureau of Materials and Physical Research Illinois Test Procedure, "Color and Gloss Retention of Finish Coats of Waterborne Acrylic Paint". The panel shall not show a color change of more than 3 Hunter Delta E Units and the 60 degrees specular gloss shall not be less than 40.
- (l) Adhesion to Inorganic Zinc. The acrylic paints shall pass the topcoat adhesion test as specified in AASHTO M 300. The inorganic zinc-rich primer shall meet the requirements of Article 1008.02.

1008.05 Organic Zinc-Rich Paint System. The organic zinc-rich paint system shall consist of an organic zinc-rich primer, an epoxy or urethane intermediate coat, and aliphatic urethane finish coats. It is intended for use over blast-cleaned steel

when three-coat shop applications are specified. The system is also suitable for field painting blast-cleaned existing structures.

The coating system shall be evaluated for performance through the National Transportation Product Evaluation Program (NTPEP) for Structural Steel Coatings following the requirements of AASHTO R 31, and shall meet the performance criteria listed herein. After successful NTPEP testing, the coatings shall be submitted to the Illinois Department of Transportation, Bureau of Materials and Physical Research, for qualification and acceptance testing.

(a) General Requirements.

- (1) Compatibility. Each coating in the system shall be supplied by the same paint manufacturer.
- (2) Toxicity. Each coating shall contain less than 0.01 percent lead in the dry film and no more than trace amounts of hexavalent chromium, cadmium, mercury, or other toxic heavy metals.
- (3) Volatile Organics. The volatile organic compounds of each coating shall not exceed 2.8 lb/gal (340 g/L) as applied.

(b) Panel Preparation for NTPEP testing. The test panels shall be prepared according to AASHTO R 31, except for the following: Test panels shall be scribed according to ASTM D 1654 with a single "X" mark centered on the panel. The rectangular dimensions of the scribe shall have a top width of 2 in. (50 mm) and a height of 4 in. (100 mm). The scribe cut shall expose the steel substrate as verified with a microscope.

(c) Zinc-Rich Primer Requirements.

- (1) Generic Type. This material shall be an organic zinc-rich epoxy or urethane primer. It shall be suitable for topcoating with epoxies, urethanes, and acrylics.
- (2) Zinc Dust. The zinc dust pigment shall comply with ASTM D 520, Type II.
- (3) Slip Coefficient. The organic zinc coating shall meet a Class B AASHTO slip coefficient (0.50 or greater) for structural steel joints using ASTM A 325 (A 325M) or A 490 (A 490M) bolts.
- (4) Adhesion. The adhesion to an abrasively blasted steel substrate shall not be less than 900 psi (6.2 MPa) when tested according to ASTM D 4541, Annex A4.
- (5) Unit Weight. The unit weight of the mixed material shall be within 0.4 lb/gal (0.048 kg/L) of the original qualification sample unit weight when tested according to ASTM D 1475.
- (6) Percent Solids by Weight of Mixed Primer. The percent solids by weight for the mixed material shall be a minimum of 70 percent and

shall not vary more than ± 2 percentage points from the percent solids by weight of the original qualification samples when tested according to ASTM D 2369.

- (7) Percent Solids by Weight of Vehicle Component. The percent solids by weight of the vehicle component shall not vary more than ± 2 percentage points from the percent solids by weight of the original qualification samples when tested according to ASTM D 2369.
 - (8) Viscosity. The viscosity of the mixed material shall not vary more than ± 10 Krebs Units from the original qualification sample viscosity when tested according to ASTM D 562 at 77 °F (25 °C).
 - (9) Dry Set to Touch. The mixed material when applied at 6 mils (150 microns) wet film thickness shall have a dry set to touch of 30 minutes or less when tested according to ASTM D 1640 at 77 °F (25 °C).
 - (10) Pot Life. After sitting eight hours at 77 °F (25 °C), the mixed material shall not show curdling, gelling, gassing, or hard caking.
- (d) Intermediate Coat Requirements.
- (1) Generic Type. This material shall be an epoxy or urethane. It shall be suitable as an intermediate coat over inorganic and organic zinc primers and compatible with acrylic, epoxy, and polyurethane topcoats.
 - (2) Color. The color of the intermediate coat shall be white, off-white, or beige.
 - (3) Unit Weight. The unit weight of the mixed material and the unit weight of the individual components shall be within 0.20 lb/gal (0.024 kg/L) of the original qualification sample unit weights when tested according to ASTM D 1475.
 - (4) Percent Solids by Weight. The percent solids by weight for the mixed material shall not vary more than ± 2 percentage points from the percent solids by weight of the original qualification samples when tested according to ASTM D 2369.
 - (5) Dry Time. The mixed material shall be dry to touch in two hours and dry hard in eight hours when applied at 10 mils (255 microns) wet film thickness and tested according to ASTM D 1640.
 - (6) Viscosity. The viscosity of the mixed material shall not vary more than ± 10 Krebs Units from the original qualification samples when tested according to ASTM D 562 at 77 °F (25 °C).
 - (7) Pot Life. After sitting two hours at 77 °F (25 °C), the mixed material shall not show curdling, gelling, gassing, or hard caking.
- (e) Urethane Finish Coat Requirements.

- (1) Generic Type. This material shall be an aliphatic urethane. It shall be suitable as a topcoat over epoxies and urethanes.
 - (2) Color and Hiding Power. The finish coat shall match Munsell Glossy Color 7.5G 4/8 Interstate Green, 2.5YR 3/4 Reddish Brown, 10B 3/6 Blue, or 5B 7/1 Gray. The color difference shall not exceed 3.0 Hunter Delta E Units. Color difference shall be measured by instrumental comparison of the designated Munsell standard to a minimum dry film thickness of 3 mils (75 microns) of sample coating produced on a test panel according to ASTM D 823, Practice E, Hand-Held, Blade Film Application. Color measurements shall be determined on a spectrophotometer with 45 degrees circumferential/zero degrees geometry, illuminant C, and two degrees observer angle. The spectrophotometer shall measure the visible spectrum from 380-720 nanometers with a wavelength interval and spectral bandpass of 10 nanometers.
 - (3) Contrast Ratio. The contrast ratio of the finish coat applied at 3 mils (75 microns) dry film thickness shall not be less than 0.99 when tested according to ASTM D 2805.
 - (4) Weathering Resistance. Test panels shall be aluminum alloy measuring 12 x 4 in. (300 x 100 mm) prepared according to ASTM D 1730, Type A, Method 1 Solvent Cleaning. A minimum dry film thickness of 3 mils (75 microns) of finish coat shall be applied to three test panels according to ASTM D 823, Practice E, Hand Held Blade Film Application. The coated panels shall be cured at least 14 days at 75 °F ± 2 °F (24 °C ± 1 °C) and 50 ± 5 percent relative humidity. The panels shall be subjected to 300 hours of accelerated weathering using the light and water exposure apparatus (fluorescent UV - condensation type) as specified in ASTM G 53-96 and ASTM G 154 (equipped with UVB-313 lamps). The cycle shall consist of eight hours UV exposure at 140 °F (60 °C) followed by four hours of condensation at 104 °F (40 °C). After exposure, rinse the panel with clean water; allow to dry at room temperature for one hour. The exposed panels shall not show a color change of more than 3 Hunter Delta E Units.
 - (5) Dry Time. The mixed material shall be dry to touch in two hours and dry hard in six hours when applied at 6 mils (150 microns) wet film thickness and tested according to ASTM D 1640.
- (f) Three Coat System Requirements.
- (1) Finish Coat Color. For NTPEP testing purposes, the color of the finish coat shall match the latest applicable AASHTO R 31 specified color.
 - (2) Salt Fog. When tested according to ASTM B 117 and evaluated according to AASHTO R 31, the paint system shall exhibit no spontaneous delamination and not exceed the following acceptance levels after scraping after 5,000 hours of salt fog exposure.

Salt Fog Acceptance Criteria		
Blister Criteria	Rust Criteria	
Conversion Value	Maximum Creep	Average Creep
9	4 mm	2 mm

- (3) Cyclic Exposure. When tested according to ASTM D 5894 and evaluated according to AASHTO R 31, the paint system shall exhibit no spontaneous delamination and not exceed the following acceptance levels after 5,000 hours of cyclic exposure.

Cyclic Exposure Acceptance Criteria		
Blister Criteria	Rust Criteria	
Conversion Value	Maximum Creep	Average Creep
9	7 mm	4 mm

- (4) Abrasion. The abrasion resistance shall be evaluated according to ASTM D 4060 using a Taber Abrader with a 2.20-lb (1000-gram) load and CS 17 wheels. The duration of the test shall be 1,000 cycles. The loss shall be calculated by difference and be less than 0.00049 lb (220 mgs).
- (5) Adhesion. The adhesion to an abrasively blasted steel substrate shall not be less than 900 psi (6.2 MPa) when tested according to ASTM D 4541, Annex A4.
- (6) Freeze Thaw Stability. There shall be no reduction of adhesion, which exceeds the test precision, after 30 days of freeze/thaw/immersion testing. One 24-hour cycle shall consist of 16 hours of approximately -22 °F (-30 °C) followed by four hours of thawing at 122 °F (50 °C) and four hours tap water immersion at 77 °F (25 °C). The test panels shall remain in the freezer mode on weekends and holidays.
- (g) Sampling, Testing, Acceptance, and Certification. Sampling, testing, acceptance, and certification of the coating system shall be according to Article 1008.01.

SECTION 1009. SOIL

1009.01 Soil for Soil Modification. When lime (slurry or dry) is used as the modifier, the soil shall have a minimum clay content of 15 percent, determined according to AASHTO T 88; and shall have a maximum organic matter content of 10 percent, determined according to AASHTO T 194.

1009.02 Soil for Lime Stabilization. The soil shall have a minimum clay content of 15 percent, determined according to AASHTO T 88; and shall have a maximum organic matter content of 10 percent, determined according to AASHTO T 194.

The soil shall also be reactive. A reactive soil is defined as a soil which when mixed thoroughly with at least three percent lime and then compacted and cured for 48 hours at 120 °F (49 °C), will exhibit a compressive strength gain of at least 50 psi (345 kPa) greater than that obtained from similarly prepared untreated control specimens. The compressive strength will be determined according to AASHTO T 208.

1009.03 Soil for Soil-Cement Base Course. The soil shall consist of the existing soil in the roadway, imported soil or aggregate, or a mixture of existing soil and imported soil, approved by the Engineer. Imported soil or aggregate shall pass a 1 1/2 in. (37.5 mm) sieve and shall contain a maximum of 15 percent retained on a 1 in. (25 mm) sieve. The soil, whether consisting entirely of existing roadway soil, imported soil or aggregate, or a mixture of existing soil and imported soil, shall all pass a 3 in. (75 mm) sieve and a maximum of 45 percent shall be retained on the No. 4 (4.75 mm) sieve.

SECTION 1010. FINELY DIVIDED MINERALS

1010.01 Description. Finely divided minerals shall include fly ash, microsilica (silica fume), high-reactivity metakaolin (HRM), and ground granulated blast-furnace slag (GGBF). The finely divided minerals will be approved according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Acceptance Procedure for Finely Divided Minerals Used in Portland Cement Concrete and Other Applications". The Department will maintain an approved list of suppliers for finely divided minerals.

Different sources or types of finely divided minerals shall not be mixed or used alternately in the same item of construction, unless approved by the Engineer.

1010.02 Fly Ash. Fly ash shall consist of the finely divided residue that results from the combustion of ground or powdered coal, transported from the combustion chamber by exhaust gas, collected by mechanical or electrical means, and stored in stockpiles or bins. Fly ash shall be according to AASHTO M 295 and the following.

- (a) Pozzolanic Mixtures (Lime-Fly Ash or Cement-Fly Ash). The fly ash shall be Class C or Class F, except if dampened for the purpose of transportation, the loss-on-ignition shall not exceed ten percent. Fly ash moisture content shall not exceed 35 percent. The fly ash when dry sieved according to Illinois Modified AASHTO T 27 shall meet the following gradation.

Sieve	Minimum Percent Passing
1/2 in. (12.5 mm)	100%
3/8 in. (9.5 mm)	95%
No.10 (2.00 mm)	75%

- (b) Portland Cement Concrete, Cement Aggregate Mixture II, Fabric Formed Concrete Revetment Mat Grout, and Insertion Lining of Pipe Culverts Grout. The fly ash shall be Class C or F.

(c) Soil Modification. The fly ash shall be Class C.

1010.03 Microsilica (silica fume). Microsilica is an amorphous silica of high silica content and purity possessing high pozzolanic activity.

The microsilica used in portland cement concrete shall be according to AASHTO M 307.

The microsilica shall be supplied either in a dry, densified form or as a water-based slurry.

1010.04 High-Reactivity Metakaolin (HRM). High-reactivity metakaolin (HRM) is a reactive aluminosilicate pozzolan formed by calcining purified kaolinite at a specific temperature range.

The HRM used in portland cement concrete shall be according to AASHTO M 321, except the fineness shall be a maximum 15 percent retained on the No. 325 (45 μm) sieve.

The HRM shall be supplied in a dry, undensified form.

1010.05 Ground Granulated Blast-Furnace (GGBF) Slag. Ground granulated blast-furnace (GGBF) slag shall consist of the glassy granular material formed when molten blast-furnace slag is rapidly chilled and then finely ground.

The GGBF slag used in portland cement concrete shall be according to AASHTO M 302, for Grade 100 or Grade 120 material.

SECTION 1011. MINERAL FILLER

1011.01 Description. Mineral filler shall consist of dry limestone dust, fly ash, cement kiln dust, or lime kiln dust; and shall be according to the following.

(a) Gradation. The gradation shall be according to the following.

Sieve	Percent Passing
No. 30 (600 μm)	100
No. 100 (150 μm)	92 \pm 8
No. 200 (75 μm)	82 \pm 18

(b) Loss on Ignition. The loss on ignition for all products shall be a maximum of five percent when tested according to the Illinois Test Procedure, "Loss on Ignition for Mineral Filler".

SECTION 1012. LIME

1012.01 Hydrated Lime. Hydrated lime shall be according to ASTM C 207.

When used in soil modification, lime stabilized soil mixture, and hot-mix asphalt (HMA), the hydrated lime shall be according to ASTM C 207, Type N.

When used in pozzolanic stabilized mixture, the hydrated lime shall be according to ASTM C 207, Type N with the following modifications.

ASTM C 25	
Parameter	Requirement
Total calcium and magnesium oxides (nonvolatile basis)	90 % min.
Free calcium oxide (as-received basis)	5 % max.
Free moisture (as-received basis)	4 % max.

ILLINOIS MODIFIED AASHTO T 27	
Sieve	Maximum Percent Retained
No. 4 (4.75 mm)	0
No. 30 (600 µm)	2.5
No. 100 (150 µm)	15

1012.02 By-Product, Hydrated Lime for Soil Modification. By-product, hydrated lime (hydrator tailings) shall be according to the following.

ASTM C 25	
Parameter	Value
Total calcium and magnesium oxides (nonvolatile basis)	90 % min.
Available calcium hydroxide (rapid sugar test, ASTM C 25) plus total MgO content calculated to be equivalent Ca(OH)_2	70 % min.
As-received loss on ignition (carbon dioxide plus moisture, combined and free)	5 % max.
Free moisture (as-received basis)	4 % max.
SO_3	10 % max.

ILLINOIS MODIFIED AASHTO T 27	
Sieve	Maximum Percent Retained
No. 4 (4.75 mm)	0
No. 30 (600 µm)	10
No. 100 (150 µm)	60

1012.03 By-Product, Non-Hydrated Lime for Soil Modification and Soil Stabilization. By-product, non-hydrated lime (lime kiln dust) shall be according to the following.

ASTM C 25	
Parameter	Value
Total calcium and magnesium oxides (nonvolatile basis)	60 % min.
Available calcium hydroxide (rapid sugar test, ASTM C 25) plus total MgO content calculated to be equivalent Ca (OH) ₂	30 % min.
As-received loss on ignition (carbon dioxide plus moisture, combined and free)	40 % max.
Free moisture (as-received basis)	4 % max.
SO ₃	10 % max.

ILLINOIS MODIFIED AASHTO T 27	
Sieve	Maximum Percent Retained
No. 4 (4.75 mm)	5
No. 30 (600 µm)	10
No. 100 (150 µm)	30

1012.04 Lime Slurry for Soil Modification and Soil Stabilization. The lime used in the slurry shall be either hydrated lime according to the requirements of ASTM C 207, Type N, or quicklime according to the requirements for calcium lime as stated in ASTM C 5.

The quantity of lime (hydrated lime or quicklime) in the slurry shall be a minimum of 35 percent and a maximum of 45 percent by total weight (mass) of slurry.

SECTION 1013. CHLORIDES

1013.01 Calcium Chloride. Calcium chloride shall be according to AASHTO M 144 and the following.

- Portland Cement Concrete Patching. The calcium chloride shall be Type L (Liquid) with a minimum of 32.0 percent by weight (mass) of calcium chloride.
- Applied. The calcium chloride shall be Type S (Solid) or Type L (Liquid). The Type S may be Grade 1, Grade 2, or Grade 3. Type L shall have a chloride concentration of 30 to 45 percent by weight (mass).

1013.02 Sodium Chloride. Sodium chloride shall be according to AASHTO M 143, Type 1, Grade 1, except that the sodium chloride (NaCl) content shall be a minimum of 96.0 percent.

PORTLAND CEMENT CONCRETE ITEMS**SECTION 1018. PACKAGED RAPID HARDENING MORTAR OR CONCRETE**

1018.01 Requirements. Packaged rapid hardening mortar or concrete shall be according to ASTM C 928 and shall be on the Department's Approved List of Packaged, Dry, Rapid Hardening Cementitious Materials for Concrete Repairs. Mixing of the mortar or concrete shall be according to the manufacturer's specifications. Water shall be according to Section 1020.

As an alternative to a packaged rapid hardening concrete, coarse aggregate may be combined with a packaged rapid hardening mortar according to the manufacturer's specifications.

SECTION 1019. CONTROLLED LOW-STRENGTH MATERIAL (CLSM)

1019.01 Description. This work shall consist of the materials, proportioning, mixing, and transporting of controlled low-strength material (CLSM).

1019.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement, Type I	1001
(b) Water	1002
(c) Fine Aggregate for Controlled Low-Strength Material (CLSM)	1003.06
(d) Fly Ash	1010
(e) Admixtures (Note 1)	

Note 1. The air-entraining admixture may be in powder or liquid form. Prior to approval, a CLSM air-entraining admixture will be evaluated in the laboratory by the Engineer. The admixture shall be able to meet the air content requirements of Mix 2. The Department will maintain an "Approved List of Air-Entraining Admixtures for Controlled Low-Strength Material (CLSM)".

1019.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Concrete Mixers	1103.01
(b) Batching and Weighing Equipment	1103.02
(c) Automatic and Semi-Automatic Batching Equipment	1103.03
(d) Mobile Portland Cement Concrete Plants	1103.04
(e) Water Supply Equipment	1103.11

1019.04 Mix Design Criteria, Mixing, and Proportioning. The mix design shall meet the following criteria.

Mix Design Criteria	
Flow	≥ 7 in. (178 mm)
Air Content	0 – 25 %
Dynamic Cone Penetration (DCP) at 3 days	≤ 1.5 in./blow (38 mm/blow)
Compressive Strength at 28 and 180 days	≥ 30 psi (207 kPa) to < 150 psi (1034 kPa)

The mix shall be produced according to Section 1020. The mixer drum shall be emptied prior to initial batch to ensure that no additional cement fines are incorporated into the mix.

The Engineer reserves the right to adjust the proportions of the mix design in the field to meet the design criteria, provide adequate flowability, maintain proper solid suspension, and meet other criteria established by the Engineer.

1019.05 Department Mix Design. The Department mix design shall be Mix 1, 2, or 3 and shall be proportioned to yield approximately one cubic yard (cubic meter).

Mix 1	
Portland Cement	50 lb (30 kg)
Fly Ash – Class C or F	125 lb (74 kg)
Fine Aggregate – Saturated Surface Dry	2900 lb (1720 kg)
Water	50-65 gal (248-322 L)
Air Content	No air is entrained

Mix 2	
Portland Cement	125 lb (74 kg)
Fine Aggregate – Saturated Surface Dry	2500 lb (1483 kg)
Water	35-50 gal (173-248 L)
Air Content	15-25 %

Mix 3	
Portland Cement	40 lb (24 kg)
Fly Ash – Class C or F	125 lb (74 kg)
Fine Aggregate – Saturated Surface Dry	2500 lb (1483 kg)
Water	35-50 gal (179-248 L)
Air Content	15-25 %

1019.06 Contractor Mix Design. A Contractor may submit their own mix design and may propose alternate fine aggregate materials, fine aggregate gradations, or material proportions.

The mix design shall include the following information.

- (a) Source of materials.
- (b) Gradation of fine aggregate.
- (c) Specific gravities, material proportions, and any other parameters used in the mix design process.
- (d) Type and proposed dosage of admixtures.
- (e) Target flow and air content.
- (f) Test data indicating compressive strength at 28 and 180 days.

If the Contractor submits a mix design which has not been previously verified by the Department, a trial batch shall be performed. The trial batch shall be scheduled a minimum of 30 calendar days prior to anticipated use and shall be performed in the presence of the Engineer. A minimum of 1 cu yd (0.75 cu m) trial batch shall be produced and placed offsite. The trial batch shall be produced with the equipment and methods intended for construction. The trial batch will be evaluated for temperature, flow, air content, dynamic cone penetration (DCP), and 28 day compressive strength by the Engineer. The Engineer reserves the right to require a 180 day compressive strength test.

Verification of the mix design will include the trial batch test results, field observations (i.e. flowability and solid suspension), and other criteria as determined by the Engineer. The Contractor will be notified in writing of verification. Verification of a mix design by the Engineer shall in no manner be construed as acceptance of any CLSM produced. The Department will maintain an "Approved List of Controlled Low-Strength Material (CLSM) Proprietary Mix Designs by Contractors".

1019.07 Sampling and Testing. The sampling and testing of CLSM shall be according to Illinois Test Procedure 307, "Sampling and Testing of Controlled Low-Strength Material (CLSM)".

The dynamic cone penetration test (DCP) shall be according to Illinois Test Procedure 501, "Dynamic Cone Penetration (DCP)".

SECTION 1020. PORTLAND CEMENT CONCRETE

1020.01 Description. This item shall consist of the materials, proportioning, mixing, transporting, curing, and protecting portland cement concrete.

1020.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement	1001
(b) Water	1002
(c) Fine Aggregate	1003
(d) Coarse Aggregate	1004
(e) Concrete Admixtures	1021
(f) Finely Divided Minerals	1010
(g) Concrete Curing Materials	1022
(h) Straw	1081.06(a)(1)
(i) Calcium Chloride	1013.01

1020.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Concrete Mixers and Trucks	1103.01
(b) Batching and Weighing Equipment	1103.02
(c) Automatic and Semi-Automatic Batching Equipment	1103.03
(d) Water Supply Equipment	1103.11
(e) Membrane Curing Equipment	1101.09
(f) Mobile Portland Cement Concrete Plants	1103.04

1020.04 Concrete Classes and General Mix Design Criteria. The classes of concrete shown in Table 1 identify the various mixtures by the general uses and mix design criteria. If the class of concrete for a specific item of construction is not specified, Class SI concrete shall be used.

Special classifications may be made for the purpose of including the concrete for a particular use or location as a separate pay item in the contract. The concrete used in such cases shall conform to this section.

TABLE 1. CLASSES OF PORTLAND CEMENT CONCRETE AND MIX DESIGN CRITERIA

TABLE 1. CLASSES OF PORTLAND CEMENT CONCRETE AND MIX DESIGN CRITERIA												
Class of Conc.	Use	Specification Section Reference	Cement Factor cwt/cu yd (3)		Water / Cement Ratio lb/lb	Sump in. (4)	Mix Design Compressive Strength (Flexural Strength)			Air Content %	Coarse Aggregate Gradations	
			Min.	Max			psi, minimum					
							3	14	28			
PV	Pavement Base Course	420 or 421										
	Base Course Widening	353										
	Driveway Pavement	354										
	Shoulders	423	5.65 (1) 6.05 (2)	7.05	0.32 - 0.42	2 - 4 (5)	Ty III 3500 (650)	3500 (650)		5.0 - 8.0	CA 5 & CA 7, CA 5 & CA 11, CA 7, CA 11, or CA 14	
	Shoulder Curb	483										
PP	Pavement Patching	662										
	Bridge Deck Patching (10)	442						3200 (600)				
	PP-1		6.50 6.20 (Ty III)	7.50 7.20 (Ty III)	0.32 - 0.44	2 - 4		at 48 hours		4.0 - 7.0	CA 7, CA 11, CA 13, CA 14, or CA 16	
	PP-2		7.35	7.35	0.32 - 0.38	2 - 6		at 24 hours		4.0 - 6.0		
	PP-3		7.35 (Ty III) (8)	7.35 (Ty III) (8)	0.32 - 0.35	2 - 4		at 16 hours		4.0 - 6.0		
RR	PP-4		6.00 (9)	6.25 (9)	0.32 - 0.50	2 - 6		at 8 hours		4.0 - 6.0		
	PP-5		6.75 (9)	6.75 (9)	0.32 - 0.40	2 - 8		at 4 hours		4.0 - 6.0	CA 13, CA 14, or CA 16	
	Railroad Crossing	422	6.50 6.20 (Ty III)	7.50 7.20 (Ty III)	0.32 - 0.44	2 - 4		3500 (650) at 48 hours		4.0 - 7.0	CA 7, CA 11, or CA 14	
	Bridge Superstructure	503	6.05	7.05	0.32 - 0.44	2 - 4 (5)		4000 (675)		5.0 - 8.0	CA 7, CA 11, or CA 14 (7)	
	Various Precast Concrete Items Wet Cast Dry Cast	1042	5.65 5.65 (Ty III)	7.05 7.05 (Ty III)	0.32 - 0.44 0.25 - 0.40	1 - 4 0 - 1	See Section 1042			5.0 - 8.0 N/A	CA 7, CA 11, CA 13, CA 14, CA 16, or CA 7 & CA 16	
PS	Precast Prestressed Members	504									CA 11 (13), CA 13, CA 14 (13), or CA 16	
	Precast Prestressed Piles and Extensions	512	5.65 5.65 (Ty III)	7.05 7.05 (Ty III)	0.32 - 0.44	1 - 4			Plans 5000	5.0 - 8.0		
	Precast Prestressed Sight Screen	639							3500			
MS	Massive Structures (except Superstructure) (11)	503	5.65 (1) 6.05 (2)	7.05	0.32 - 0.46	2 - 4		3500 (650)		5.0 - 8.0	CA 3 & CA 7, CA 3 & CA 11, CA 5 & CA 7, CA 5 & CA 11, CA 7, or CA 11	

TABLE 1. CLASSES OF PORTLAND CEMENT CONCRETE AND MIX DESIGN CRITERIA

TABLE 1. CLASSES OF PORTLAND CEMENT CONCRETE AND MIX DESIGN CRITERIA												
Class of Conc.	Use	Specification Section Reference	Cement Factor cwt/cu yd (3)		Water / Cement Ratio lb/lb	Sump in. (4)	Mix Design Compressive Strength (Flexural Strength) psi, minimum				Air Content %	Coarse Aggregate Gradations
			Min.	Max			Days					
							3	14	28			
DS	Drilled Shaft (12)	516	6.65	7.05	0.32 - 0.44	6 - 8 (6)	4000 (675)			5.0 - 8.0	CA 13, CA 14, CA 16, or a blend of these gradations.	
	Metal Shell Piles (12)	512										
	Sign Structures	734										
	Drilled Shaft (12)	837										
	Light Tower Foundation (12)											
SC	Seal Coat	503	5.65 (1) 6.05 (2)	7.05	0.32 - 0.46	3 - 5	3500 (650)			N/A	CA 3 & CA 7, CA 3 & CA 11, CA 5 & CA 7, CA 7 & CA 11, CA 7, or CA 11	
SI	Structures (except Superstructure)	503										
	Sidewalk	424										
	Slope Wall	511										
	Encasement	512										
	Box Culverts	540										
	End Section and Collar	542										
	Curb, Gutter, Curb & Gutter, Median, and Paved Ditch											
	Concrete Barrier	606										
	Sign Structures	637										
	Spread Footing	734										
	Concrete Foundation											
	Pole Foundation (12)											
	Traffic Signal Foundation	836										
	Drilled Shaft (12)	878										
		Square or Rectangular										

Notes:

- (1) Central mixed.
- (2) Truck mixed or shrink mixed.
- (3) For Class SC concrete and for any other class of concrete that is to be placed underwater, except Class DS concrete, the cement factor shall be increased by ten percent.
- (4) The maximum slump may be increased to 7 in. when a high range water-reducing admixture is used for all classes of concrete, except Class PV, SC, and PP. For Class SC, the maximum slump may be increased to 8 in. For Class PP-1, the maximum slump may be increased to 6 in. For Class PS, the 7 in. maximum slump may be increased to 8 1/2 in. if the high range water-reducing admixture is the polycarboxylate type.
- (5) The slump range for slipform construction shall be 1/2 to 1 1/2 in.
- (6) If concrete is placed to displace drilling fluid, or against temporary casing, the slump shall be 8 - 10 in. at the point of placement. If a water-reducing admixture is used per Article 1020.05(b)(8), the slump shall be 2 - 4 in.
- (7) For Class BS concrete used in bridge deck patching, the coarse aggregate gradation shall be CA 13, CA 14, or CA 16, except CA 11 may be used for full-depth patching.
- (8) In addition to the cement, 100 lb/cu yd of ground granulated blast-furnace slag and 50 lb/cu yd of microsilica (silica fume) shall be used. For an air temperature greater than 85 °F, the Type III cement may be replaced with Type I or II cement.
- (9) The cement shall be a rapid hardening cement from the Department's "Approved List of Packaged, Dry, Rapid Hardening Cementitious Materials for Concrete Repairs" for PP-4 and calcium aluminate cement for PP-5.
- (10) For Class PP concrete used in bridge deck patching, the aggregate gradation shall be CA 13, CA 14, or CA 16, except CA 11 may be used for full-depth patching. In addition, the mix design shall have 72 hours to obtain a 4,000 psi compressive or 675 psi flexural strength for all PP mix designs.
- (11) At the Contractor's option, Class SI concrete may be used when Class MS concrete is specified.
- (12) The concrete mix shall be designed to remain fluid throughout the anticipated duration of the pour plus one hour. At the Engineer's discretion, the Contractor may be required to conduct a minimum 2 cu yd trial batch to verify the mix design.
- (13) The nominal maximum size permitted is 3/4 in. Nominal maximum size is defined as the largest sieve which retains any of the aggregate sample particles.

TABLE 1. CLASSES OF PORTLAND CEMENT CONCRETE AND MIX DESIGN CRITERIA (metric)

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Class of Conc.	Use	Specification Section Reference	Cement Factor kg/cu m (3)		Water / Cement Ratio kg/kg	S u p mm (4)	Mix Design Compressive Strength (Flexural Strength) kPa, minimum			Air Content %	Coarse Aggregate Gradations	
			Min.	Max			Days	3	14			28
PV	Pavement Base Course	420 or 421										
	Base Course Widening	353										
	Driveway Pavement	423	335 (1)	418	0.32 - 0.42	50 - 100 (5)	Ty III	24,000 (4500)		5.0 - 8.0	CA 5 & CA 7, CA 5 & CA 11, or CA 14	
	Shoulders	483	360 (2)									
	Shoulder Curb	662										
PP	Pavement Patching											
	Bridge Deck Patching (10)	442										
	PP-1		385 (Ty III)	445 (Ty III)	0.32 - 0.44	50 - 100	at 48 hours		4.0 - 7.0	CA 7, CA 11, CA 13, CA 14, or CA 16		
	PP-2		435 (Ty III)	435 (Ty III)	0.32 - 0.38	50 - 150	at 24 hours		4.0 - 6.0			
	PP-3		435 (Ty III)	435 (Ty III)	0.32 - 0.35	50 - 100	at 16 hours		4.0 - 6.0			
RR	PP-4		355 (9)	370 (9)	0.32 - 0.50	50 - 150	at 8 hours		4.0 - 6.0			
	PP-5		400 (9)	400 (9)	0.32 - 0.40	50 - 200	at 4 hours		4.0 - 6.0	CA 13, CA 14, or CA 16		
	Railroad Crossing	422	385 (Ty III)	445 (Ty III)	0.32 - 0.44	50 - 100	24,000 (4500) at 48 hours		4.0 - 7.0	CA 7, CA 11, or CA 14		
	BS	503	360	418	0.32 - 0.44	50 - 100 (5)	27,500 (4650)		5.0 - 8.0	CA 7, CA 11, or CA 14 (7)		
	PC	Various Precast Concrete Items	1042	335 (Ty III)	418 (Ty III)	0.32 - 0.44	25 - 100	See Section 1042	5.0 - 8.0	CA 7, CA 11, CA 13, CA 14, CA 16, or CA 7 & CA 16		
PS	Wet Cast Dry Cast				0.25 - 0.40	0 - 25			N/A			
	Precast Prestressed Members	504	335 (Ty III)	418 (Ty III)	0.32 - 0.44	25 - 100	Plans		5.0 - 8.0	CA 11 (13), CA 13, CA 14 (13), or CA 16		
	Precast Prestressed Piles and Extensions	512	335 (Ty III)	418 (Ty III)			34,500					
MS	Precast Prestressed Sight Screen	639						24,000 (4500)				
	Massive Structures (except Superstructure) (11)	503	335 (1)	418	0.32 - 0.46	50 - 100			5.0 - 8.0	CA 3 & CA 7, CA 3 & CA 11, CA 5 & CA 7, CA 5 & CA 11, or CA 11		

TABLE 1. CLASSES OF PORTLAND CEMENT CONCRETE AND MIX DESIGN CRITERIA (metric)											
Class of Conc.	Use	Specification Section Reference	Cement Factor kg/cu m (3)		Water / Cement Ratio kg/kg	Sump mm (4)	Mix Design Compressive Strength (Flexural Strength) kPa, minimum			Air Content %	Coarse Aggregate Gradations
			Min.	Max			Days				
							3	14	28		
DS	Drilled Shaft (12)	516	395	418	0.32 - 0.44	150-200 (6)	27,500 (4650)		5.0 - 8.0	CA 13, CA 14, CA 16, or a blend of these gradations.	
	Metal Shell Piles (12)	512									
	Sign Structures	734									
	Drilled Shaft (12)										
	Light Tower Foundation (12)	837									
SC	Seal Coat	503	335 (1) 360 (2)	418	0.32 - 0.46	75 - 125	24,000 (4500)		N/A	CA 3 & CA 7, CA 3 & CA 11, CA 5 & CA 7, CA 7 & CA 11, CA 7, or CA 11	
SI	Structures (except Superstructure)	503									
	Sidewalk	424									
	Slope Wall	511									
	Encasement	512									
	Box Culverts	540									
	End Section and Collar	542									
	Curb, Gutter, Curb & Gutter, Median, and Paved Ditch										
	Concrete Barrier	606									
	Concrete Barrier	637									
	Sign Structures	734									
	Spread Footing										
	Concrete Foundation										
	Pole Foundation (12)	836									
	Traffic Signal Foundation	878									
	Drilled Shaft (12)										
	Square or Rectangular										

Notes:

- (1) Central mixed.
- (2) Truck mixed or shrink mixed.
- (3) For Class SC concrete and for any other class of concrete that is to be placed underwater, except Class DS concrete, the cement factor shall be increased by ten percent.
- (4) The maximum slump may be increased to 175 mm when a high range water-reducing admixture is used for all classes of concrete except Class PV, SC, and PP. For Class SC, the maximum slump may be increased to 200 mm. For Class PP-1, the maximum slump may be increased to 150 mm. For Class PS, the 175 mm maximum slump may be increased to 215 mm if the high range water-reducing admixture is the polycarboxylate type.
- (5) The slump range for slipform construction shall be 13 to 40 mm.
- (6) If concrete is placed to displace drilling fluid, or against temporary casing, the slump shall be 200 - 250 mm at the point of placement. If a water-reducing admixture is used per Article 1020.05(b)(8), the slump shall be 50 - 100 mm.
- (7) For Class BS concrete used in bridge deck patching, the coarse aggregate gradation shall be CA 13, CA 14, or CA 16, except CA 11 may be used for full-depth patching.
- (8) In addition to the cement, 60 kg/cu m of ground granulated blast-furnace slag and 30 kg/cu m of microsilica (silica fume) shall be used. For an air temperature greater than 30 °C, the Type III cement may be replaced with Type I or II cement.
- (9) The cement shall be a rapid hardening cement from the Department's "Approved List of Packaged, Dry, Rapid Hardening Cementitious Materials for Concrete Repairs" for PP-4 and calcium aluminate cement for PP-5.
- (10) For Class PP concrete used in bridge deck patching, the aggregate gradation shall be CA 13, CA 14, or CA 16, except CA 11 may be used for full-depth patching. In addition, the mix design shall have 72 hours to obtain a 27,500 kPa compressive or 4,650 kPa flexural.
- (11) At the Contractor's option, Class SI concrete may be used when Class MS concrete is specified.
- (12) The concrete mix shall be designed to remain fluid throughout the anticipated duration of the pour plus one hour. At the Engineer's discretion, the Contractor may be required to conduct a minimum 1.5 cu m trial batch to verify the mix design.
- (13) The nominal maximum size permitted is 19 mm. Nominal maximum size is defined as the largest sieve which retains any of the aggregate sample particles.

1020.05 Other Concrete Criteria. The portland cement concrete shall be according to the following.

- (a) Proportioning. For Class PC and Class PS concrete, it shall be the Contractor's responsibility to determine the material proportions and to exercise mixture quality control so that each batch of concrete will meet specifications herein. Before the work begins, the concrete material proportions shall be approved by the Engineer.

For all other classes of concrete, the Engineer will determine the proportions of materials for the concrete. The Engineer will furnish to prospective bidders, upon request, the approximate proportions by weight (mass) necessary to produce concrete having the specified criteria. This information is only for the convenience of the bidder.

The Engineer reserves the right to determine, as the work progresses, the mortar factor and proportions of materials which will produce concrete meeting the specified criteria. The mortar factor and proportions will be determined according to the procedure established in the current "Portland Cement Concrete Level III Technician Course - Manual of Instructions for Design of Concrete Mixtures".

- (b) Admixtures. The use of admixtures to increase the workability or to accelerate the hardening of the concrete will be permitted when approved by the Engineer. The Department will maintain an Approved List of Corrosion Inhibitors. Corrosion inhibitor dosage rates shall be according to Article 1020.05(b)(12). The Department will also maintain an Approved List of Concrete Admixtures and will include instructions for determining the dosage of an admixture on the list. The Engineer reserves the right to determine the admixture dosage. An admixture dosage or combination of admixture dosages shall not delay the initial set of concrete by more than one hour.

The sequence, method, and equipment for adding the admixtures shall be approved by the Engineer. Admixtures shall be added to the concrete separately. An accelerator shall always be added prior to a high range water-reducing admixture, if both are used.

Admixture use shall be according to the following.

- (1) When the atmosphere or concrete temperature is 65 °F (18 °C) or higher, a retarding admixture shall be used in the Class BS concrete and portland cement concrete bridge deck overlays. The proportions of the ingredients of the concrete shall be the same as without the retarding admixture, except that the amount of mixing water shall be reduced, as may be necessary, in order to maintain the consistency of the concrete as required. In addition, a high range water-reducing admixture shall be used in bridge deck concrete. At the option of the Contractor, a water-reducing admixture may be used.
- (2) For Class PC and PS concrete, a retarding admixture may be added to the concrete mixture when the concrete temperature is 65 °F (18 °C) or

higher. The use of a retarding admixture at a lower temperature or the use of other admixtures may be done when approved by the Engineer, or if specified by the contract. When an accelerating admixture is permitted by the Engineer, it shall be the non-chloride type.

- (3) At the Contractor's option, admixtures in addition to an air-entraining admixture may be used for Class PP-1 or RR concrete. The accelerator shall be the non-chloride type. When the air temperature is less than 55 °F (13 °C), the non-chloride accelerator shall be calcium nitrite. When a water-reducing or retarding admixture is used, the cement factor may be reduced a maximum 0.30 hundredweight/cu yd (18 kg/cu m). When a high range water-reducing admixture is used, the cement factor may be reduced a maximum 0.60 hundredweight/cu yd (36 kg/cu m). Cement factor reductions shall not be cumulative when using multiple admixtures.
- (4) When Class C fly ash or ground granulated blast-furnace slag is used in Class PP-1 or RR concrete, a water-reducing or high range water-reducing admixture shall be used. However, the cement factor shall not be reduced if a water-reducing, retarding, or high range water-reducing admixture is used. An accelerator shall not be used with Class C fly ash.
- (5) For Class PP-2 or PP-3 concrete, a non-chloride accelerator followed by a high range water-reducing admixture shall be used, in addition to the air-entraining admixture. For Class PP-3 concrete, the non-chloride accelerator shall be calcium nitrite. For Class PP-2 concrete, the non-chloride accelerator shall be calcium nitrite when the air temperature is less than 55 °F (13 °C).

The Contractor has the option to use a water-reducing admixture. A retarding admixture shall not be used unless approved by the Engineer. A water-reducing, retarding, or high range water-reducing admixture shall not be used to reduce the cement factor.

- (6) For Class PP-4 concrete, a high range water-reducing admixture shall be used in addition to the air-entraining admixture. The Contractor has the option to use a water-reducing admixture. An accelerator shall not be used. For stationary or truck mixed concrete, a retarding admixture shall be used to allow for haul time. The Contractor has the option to use a mobile portland cement concrete plant, but a retarding admixture shall not be used unless approved by the Engineer. A water-reducing, retarding, or high range water-reducing admixture shall not be used to reduce the cement factor.

For PP-5 concrete, a non-chloride accelerator, high range water-reducing admixture, and air-entraining admixture shall be used. The accelerator, high range water-reducing admixture, and air-entraining admixture shall be per the Contractor's recommendation and dosage. The approved list of concrete admixtures shall not apply. A mobile portland cement concrete plant shall be used to produce the patching

mixture. The high range water-reducing admixture shall not be used to reduce the cement factor.

- (7) When a calcium chloride accelerator for Class PP-1 concrete is specified in the contract, the maximum chloride dosage shall be 1.0 quart (1.0 L) of solution per 100 lb (45 kg) of cement. The dosage may be increased to a maximum 2.0 quarts (2.0 L) per 100 lb (45 kg) of cement if approved by the Engineer. When a calcium chloride accelerator for Class PP-2 concrete is specified in the contract, the maximum chloride dosage shall be 1.3 quarts (1.3 L) of solution per 100 lb (45 kg) of cement. The dosage may be increased to a maximum 2.6 quarts (2.6 L) per 100 lb (45 kg) of cement if approved by the Engineer.
- (8) For Class DS concrete a retarding admixture and a high range water-reducing admixture shall be used. For dry excavations that are 10 ft (3 m) or less, the high range water-reducing admixture may be replaced with a water-reducing admixture if the concrete is vibrated. If an accelerating admixture is permitted by the Engineer, it shall be the non-chloride type.
- (9) At the Contractor's option, a water-reducing admixture or a retarding admixture may be used for Class PV, MS, SC, and SI concrete.

When a water-reducing admixture is added, a cement factor reduction of up to 0.30 hundredweight/cu yd (18 kg/cu m), from the concrete designed for a specific slump without the admixture, will be permitted. When an approved high range water-reducing admixture is used, a cement factor reduction of up to 0.60 hundredweight/cu yd (36 kg/cu m), from a specific water cement/ratio without the admixture, will be permitted based on a 14 percent minimum water reduction. A cement factor below 5.35 hundredweight/cu yd (320 kg/cu m) will not be permitted. A cement factor reduction will not be allowed for concrete placed underwater. Cement factor reductions shall not be cumulative when using multiple admixtures.

- (10) For Class PV, MS, and SI, a retarding admixture shall be added to the concrete mixture when the concrete temperature is 85 °F (30 °C) or higher. This requirement may be waived by the Engineer when fly ash compensated mixtures are used.
- (11) When Type F or Type G high range water-reducing admixtures are used, the following restrictions shall apply.
 - a. The Type F or Type G admixture shall be added at the jobsite, unless otherwise approved by the Engineer. The initial slump shall be a minimum of 1 1/2 in. (40 mm) prior to addition of the Type F or Type G admixture, except as approved by the Engineer.
 - b. When a Type G admixture is used, retempering with water or with a Type G admixture will not be allowed.

When a Type F admixture is used, retempering with water will not be allowed. An additional dosage of a Type F admixture, not to exceed 40 percent of the original dosage, may be used to retemper concrete, provided set time is not unduly affected. A second retempering with a Type F admixture may be used for all classes of concrete, except Class PP and SC, provided that the dosage does not exceed the dosage used for the first retempering, and provided that the set time is not unduly affected.

- (12) When specified, a corrosion inhibitor shall be added to the concrete mixture utilized in the manufacture of precast, prestressed concrete members and/or other applications. It shall be added, at the same rate, to all grout around post-tensioning steel when specified.

When calcium nitrite is used, it shall be added at the rate of 4 gal/cu yd (20 L/cu m), and shall be added to the mix immediately after all compatible admixtures have been introduced to the batch.

When Rheocrete 222+ is used, it shall be added at the rate of 1.0 gal/cu yd (5.0 L/cu m), and the batching sequence shall be according to the manufacturer's instructions.

- (c) Finely Divided Minerals. Use of finely divided minerals shall be according to the following.

- (1) Fly Ash. At the Contractor's option, fly ash from approved sources may partially replace portland cement in concrete mixtures, for Class PV, PP-1, RR, BS, PC, PS, MS, DS, SC, and SI, except when blended cements are used. A mix design consisting of cement, fly ash, and ground granulated blast-furnace slag may be used only when specified by the Department.

Fly ash and all other materials proposed for portland cement concrete mix designs shall be furnished to the Engineer at least 60 days prior to the initiation of work. The Engineer may elect to waive the required mix designs if the proposed materials combination has been previously approved and has demonstrated satisfactory field performance.

The use of fly ash shall be according to the following.

- a. Measurements of fly ash and cement will be rounded up to the nearest 5 lb (2.5 kg).
- b. When Class F fly ash is used in Class PV, MS, SC, and SI concrete, the amount of cement replaced shall not exceed 15 percent by weight (mass) and the replacement ratio (fly ash:cement replaced) shall be a minimum of 1.5:1.
- c. When Class C fly ash is used in Class PV, MS, SC, and SI concrete, the amount of cement replaced shall not exceed 20 percent by weight (mass), at a minimum replacement ratio of 1.25:1. For Class C fly ash, the minimum replacement ratio may be

reduced to 1:1, if the fly ash calcium oxide is 18 percent or greater, the fly ash loss on ignition is less than 2.0 percent, and a water-reducing or high range water-reducing admixture is used.

- d. For Class BS and DS concrete, the amount of cement replaced shall not exceed 15 percent by weight (mass) at a minimum replacement ratio of 1.5:1, regardless of the type of fly ash used.
 - e. For Class PP-1 and RR concrete, the Type I cement may be replaced with Class C fly ash. The amount of cement replaced shall be a maximum of 15 percent by weight (mass), at a minimum replacement ratio of 1.5:1.
 - f. For precast concrete products using Class PC concrete, Class F fly ash shall not exceed 15 percent by weight (mass). Class C fly ash shall not exceed 20 percent by weight (mass). The replacement ratio (fly ash:cement replaced) shall be a minimum of 1:1 for either Class F or C.
 - g. For Class PS concrete, the amount of Class C or F fly ash shall not exceed 15 percent by weight (mass). The replacement ratio (fly ash:cement replaced) shall be a minimum of 1:1. The amount of cement shall not be reduced below 565 lbs/cu yd (335 kg/cu m).
 - h. Fly ash shall not be used in concrete mixtures when the air temperature is below 40 °F (4 °C) without permission of the Engineer. If permission is given, the mix design strength requirement may require the Contractor to reduce the quantity of fly ash, increase the cement, or eliminate the cement factor reduction for a water-reducing or high range water-reducing admixture which is permitted according to Article 1020.05(b).
- (2) Ground Granulated Blast-Furnace (GGBF) Slag. At the Contractor's option, GGBF slag may partially replace portland cement in concrete mixtures, for Class PV, PP-1, PP-2, RR, BS, PC, PS, MS, DS, SC, and SI, except when blended cements are used. For Class PP-3 concrete, GGBF slag shall be used according to Article 1020.04. A mix design consisting of cement, GGBF slag, and fly ash may be used only when specified by the Department.

GGBF slag and all other materials proposed for portland cement concrete mix designs shall be furnished to the Engineer at least 60 days prior to the initiation of work. The Engineer may elect to waive the required mix designs if the proposed materials combination has been previously approved and has demonstrated satisfactory field performance.

The use of GGBF slag shall be according to the following.

- a. Measurements of GGBF slag and cement shall be rounded up to the nearest 5 lb (2.5 kg).

- b. When GGBF slag is used in Class BS, PV, MS, SI, DS, and SC concrete, the amount of cement replaced shall not exceed 25 percent by weight (mass). The replacement ratio (GGBF slag:cement replaced) shall be a minimum of 1:1 for Grade 100 and 120.
 - c. For Class PP-1 and RR concrete, the Type I cement may be replaced with GGBF slag at a maximum amount of 15 percent by weight (mass), at a minimum replacement ratio of 1.5:1.
 - d. For Class PP-2 concrete, the Type I cement may be replaced with GGBF slag at a maximum amount of 30 percent by weight (mass), at a minimum replacement ratio of 1:1.
 - e. For precast concrete products using Class PC concrete, GGBF slag shall not exceed 25 percent by weight (mass). The replacement ratio (slag:cement replaced) shall be a minimum of 1:1.
 - f. For Class PS concrete, the amount of GGBF slag shall not exceed 15 percent by weight (mass). The replacement ratio (slag:cement replaced) shall be a minimum of 1:1. The amount of cement shall not be reduced below 565 lbs/cu yd (335 kg/cu m).
 - g. Except for Class PP-3 concrete, GGBF slag shall not be used in concrete mixtures when the air temperature is below 40 °F (4 °C) without permission of the Engineer. If permission is given, the mix design strength requirement may require the Contractor to reduce the quantity of GGBF slag, increase the cement, or eliminate the cement factor reduction for a water-reducing or high range water-reducing admixture which is permitted according to Article 1020.05(b).
- (3) Microsilica. At the Contractor's option, microsilica may be used in Class PS concrete. The amount of microsilica used shall be approved by the Engineer. Microsilica may also be used in a concrete mixture when approved by the Engineer.

Microsilica shall be used in Class PP-3 concrete according to Article 1020.04.

- (4) High Reactivity Metakaolin (HRM). At the Contractor's option, HRM may be used in Class PS concrete. The amount of HRM used shall be approved by the Engineer. HRM may also be used in a concrete mixture when approved by the Engineer.

1020.06 Water/Cement Ratio. The water/cement ratio shall be determined on a weight (mass) basis. When a maximum water/cement ratio is specified, the water shall include wash water, mixing water, water in admixtures, free moisture on the aggregates, and water added at the jobsite. The quantity of water may be adjusted by the Engineer, within the limit specified, to meet slump requirements.

When fly ash, ground granulated blast-furnace slag, high-reactivity metakaolin, or microsilica (silica fume) are used in a concrete mix, the water/cement ratio will be based on the total cement and finely divided minerals contained in the mixture.

1020.07 Slump. The slump shall be determined according to Illinois Modified AASHTO T 119.

If the measured slump falls outside the limits specified, a check test will be made. In the event of a second failure, the Engineer may refuse to permit the use of the batch of concrete represented.

If it is found impossible to prepare concrete of the specified slump without exceeding the maximum design water/cement ratio, additional cement or a water reducing admixture shall be added at no additional cost to the Department.

1020.08 Air Content. The air content shall be determined according to Illinois Modified AASHTO T 152 or Illinois Modified AASHTO T 196. The air-entrainment shall be obtained by the use of portland cement with an approved air-entraining admixture added during the mixing of the concrete or the use of air-entraining cement when specified or approved by the Engineer.

If the air-entraining portland cement furnished is found to produce concrete having an air content outside the limits specified, its use shall be discontinued immediately and the Contractor shall provide other air-entraining portland cement which will produce air contents within the specified limits.

If the air content obtained is above the specified maximum limit at the jobsite, the Contractor, with the Engineer's approval, may add to the truck mixer non air-entraining portland cement in the proportion necessary to bring the air content within the specified limits, or the concrete may be further mixed, within the limits of time and revolutions specified, to reduce the air content. If the air content obtained is below the specified minimum limit, the Contractor may add to the concrete during the process of mixing, a sufficient quantity of an approved air-entraining admixture at the jobsite to bring the air content within the specified limits.

1020.09 Strength Tests. The specimens shall be molded and cured according to Illinois Modified AASHTO T 23. Specimens shall be field cured with the construction item as specified in Illinois Modified AASHTO T 23. The compressive strength shall be determined according to Illinois Modified AASHTO T 22. The flexural strength shall be determined according to Illinois Modified AASHTO T 177.

Except for Class PC and PS concrete, the Contractor shall transport the strength specimens from the site of the work to the field laboratory or other location as instructed by the Engineer. During transportation in a suitable light truck, the specimens shall be embedded in straw, burlap, or other acceptable material in a manner meeting with the approval of the Engineer to protect them from damage; care shall be taken to avoid impacts during hauling and handling. For flexural strength specimens, the Contractor shall provide a water storage tank for curing.

1020.10 Handling, Measuring, and Batching Materials. Aggregates shall be handled in a manner to prevent mixing with soil and other foreign material.

Aggregates shall be handled in a manner which produces a uniform gradation, before placement in the plant bins. Aggregates delivered to the plant in a nonuniform gradation condition shall be stockpiled. The stockpiled aggregate shall be mixed uniformly before placement in the plant bins.

Aggregates shall have a uniform moisture content before placement in the plant bins. This may require aggregates to be stockpiled for 12 hours or more to allow drainage, or water added to the stockpile, or other methods approved by the Engineer. Moisture content requirements for crushed slag shall be according to Article 1004.01(e).

Aggregates, cement, and finely divided minerals shall be measured by weight (mass). Water and admixtures shall be measured by volume or weight (mass).

The Engineer may permit aggregates, cement, and finely divided minerals to be measured by volume for small isolated structures and for miscellaneous items. Aggregates, cement, and finely divided minerals shall be measured individually. The volume shall be based upon dry, loose materials.

1020.11 Mixing Portland Cement Concrete. The mixing of portland cement concrete shall be according to the following.

- (a) Ready-Mixed Concrete. Ready-mixed concrete is central mixed, truck mixed, or shrink mixed concrete transported and delivered in a plastic state ready for placement in the work and shall be according to the following.
 - (1) Central-Mixed Concrete. Central mixed concrete is concrete which has been completely mixed in a stationary mixer and delivered in a truck agitator, a truck mixer operating at agitating speed, or a nonagitator truck.

The stationary mixer shall operate at the drum speed for which it was designed. The batch shall be charged into the drum so that some of the water shall enter in advance of the cement, finely divided minerals, and aggregates. The flow of the water shall be uniform and all water shall be in the drum by the end of the first 15 seconds of the mixing period. Water shall begin to enter the drum from zero to two seconds in advance of solid material and shall stop flowing within two seconds of the beginning of mixing time.

Some coarse aggregate shall enter in advance of other solid materials. For the balance of the charging time for solid materials, the aggregates, finely divided minerals, and cement (to assure thorough blending) shall each flow at acceptably uniform rates, as determined by visual observation. Coarse aggregate shall enter two seconds in advance of other solid materials and a uniform rate of flow shall continue to within two seconds of the completion of charging time.

The entire contents of the drum, or of each single compartment of a multiple-drum mixer, shall be discharged before the succeeding batch is introduced.

The volume of concrete mixed per batch shall not exceed the mixer's rated capacity as shown on the standard rating plate on the mixer by more than ten percent.

The minimum mixing time shall be 75 seconds for a stationary mixer having a capacity greater than 2 cu yd (1.5 cu m). For a mixer with a capacity equal to or less than 2 cu yd (1.5 cu m) the mixing time shall be 60 seconds. Transfer time in multiple drum mixers is included in the mixing time. Mixing time shall begin when all materials are in the mixing compartment and shall end when the discharge of any part of the batch is started. The required mixing times will be established by the Engineer for all types of stationary mixers.

When central-mixed concrete is to be transported in a truck agitator or a truck mixer, the stationary-mixed batch shall be transferred to the agitating unit without delay and without loss of any portion of the batch. Agitating shall start immediately thereafter and shall continue without interruption until the batch is discharged from the agitator. The ingredients of the batch shall be completely discharged from the agitator before the succeeding batch is introduced. Drums and auxiliary parts of the equipment shall be kept free from accumulations of materials.

The vehicles used for transporting the mixed concrete shall be of such capacity, or the batches shall be so proportioned, that the entire contents of the mixer drum can be discharged into each vehicle load.

- (2) **Truck-Mixed Concrete.** Truck-mixed concrete is completely mixed and delivered in a truck mixer. When the mixer is charged with fine and coarse aggregates simultaneously, not less than 60 nor more than 100 revolutions of the drum or blades at mixing speed shall be required, after all of the ingredients including water are in the drum. When fine and coarse aggregates are charged separately, not less than 70 revolutions will be required. Additional mixing beyond 100 revolutions shall be at agitating speed unless additions of water and/or admixtures are made at the direction of the Engineer. The mixing operation shall begin immediately after the cement and water, or the cement and wet aggregates, come in contact. The ingredients of the batch shall be completely discharged from the drum before the succeeding batch is introduced. The drum and auxiliary parts of the equipment shall be kept free from accumulations of materials. If additional water or an admixture is added at the jobsite, the concrete batch shall be mixed a minimum of 40 additional revolutions after each addition.
- (3) **Shrink-Mixed Concrete.** Shrink-mixed concrete is mixed partially in a stationary mixer and completed in a truck mixer for delivery. The mixing time of the stationary mixer may be reduced to a minimum of 30 seconds to intermingle the ingredients, before transferring to the truck mixer. All ingredients for the batch shall be in the stationary mixer and partially mixed before any of the mixture is discharged into the truck mixer. The partially mixed batch shall be transferred to the truck mixer without delay and without loss of any portion of the batch, and mixing in

the truck mixer shall start immediately. The mixing time in the truck mixer shall be not less than 50 nor more than 100 revolutions of the drum or blades at mixing speed. Additional mixing beyond 100 revolutions shall be at agitating speed, unless additions of water and/or admixtures are made at the direction of the Engineer. Units designed as agitators shall not be used for shrink mixing. The ingredients of the batch shall be completely discharged from the drum before the succeeding batch is introduced. The drum and auxiliary parts of the equipment shall be kept free from accumulations of materials. If additional water or an admixture is added at the jobsite, the concrete batch shall be mixed a minimum of 40 additional revolutions after each addition.

- (4) **Mixing Water.** No additional water may be added at the jobsite to central-mixed concrete if a reduction in the cement factor has been given for central-mixed concrete.

All mixing water shall be added at the plant and no water may be added at the jobsite to exceed the design slump.

Wash water, if used, shall be either completely discharged from the drum or container before the succeeding batch is introduced, or if permitted by the Engineer, remain as a portion of the mixing water for the succeeding batch, and shall be accurately measured and taken into account in determining the amount of additional mixing water required.

- (5) **Mixing and Agitating Speeds.** The mixing speed for the revolving drum type of truck mixer shall be the manufacturer's recommended speed as displayed on the rating plate. If the concrete is inadequately mixed, the mixing speed shall be not less than five revolutions per minute of the drum, nor greater than a speed resulting in a peripheral velocity of the drum of 225 ft/min (69 m/min). For the revolving blade type of mixer, the mixing speed shall be not less than five nor more than 16 revolutions per minute of the mixing blades.

Agitating speed, for both the revolving drum and revolving blade types, shall be not less than two nor more than five revolutions per minute of the drum or of the mixing blades.

- (6) **Capacities.** The volume of plastic concrete in a given batch will be determined according to AASHTO T 121, based on the total weight (mass) of the batch, determined either from the weight (masses) of all materials, including water, entering the batch or directly from the net weight (mass) of the concrete in the batch as delivered.

The volume of mixed concrete in truck mixers or truck agitators shall in no case be greater than the rated capacity determined according to the Truck Mixer, Agitator, and Front Discharge Concrete Carrier Standards of the Truck Mixer Manufacturer's Bureau, as shown by the rating plate attached to the truck. If the truck mixer does not have a rating plate, the volume of mixed concrete shall not exceed 63 percent of the gross

volume of the drum or container, disregarding the blades. For truck agitators, the value is 80 percent.

For the purpose of determining the gross volume of the container of the revolving blade type of truck mixer or agitator, the height of the container above the center shaft will be considered no greater than the radius of the circular section of the container below the center shaft, and the overall width will be considered no greater than the diameter of the circular section.

- (7) Time of Haul. Haul time shall begin when the delivery ticket is stamped. The delivery ticket shall be stamped no later than five minutes after the addition of the mixing water to the cement, or after the addition of the cement to the aggregate when the mixer drum contains residual water or the combined aggregates contain free moisture in excess of two percent by weight (mass). If more than one batch is required for charging a truck using a stationary mixer, the time of haul shall start with mixing of the first batch. Haul time shall end when the truck is emptied for incorporation of the concrete into the work.

The time elapsing from when water is added to the mix until it is deposited in place at the site of the work shall not exceed 30 minutes when the concrete is transported in nonagitating trucks.

Concrete transported in truck mixers or truck agitators shall be delivered to the site of the work in a plastic and workable condition, satisfactory for placement in the work without the addition of water or water and cement prior to discharging.

The maximum haul time for concrete transported in truck mixers or truck agitators shall be according to the following.

Concrete Temperature at Point of Discharge °F (°C)	Haul Time	
	Hours	Minutes
50-64 (10-17.5)	1	30
65-90 (18-32) - without retarder	1	0
65-90 (18-32) - with retarder	1	30

To encourage start-up testing for mix adjustments at the plant, the first two trucks will be allowed an additional 15 minutes haul time whenever such testing is performed.

For a mixture which is not mixed on the jobsite, a delivery ticket shall be required for each load. The following information shall be recorded on each delivery ticket: (1) ticket number; (2) name of producer; (3) contract number; (4) name of Contractor; (5) stamped date and time batched; (6) truck number; (7) quantity batched; (8) amount of admixture(s) in the batch; (9) amount of water in the batch; and (10) Department mix design number.

For concrete mixed in jobsite stationary mixers, the above delivery ticket may be waived, but a method of verifying the haul time shall be established to the satisfaction of the Engineer.

- (8) **Production and Delivery.** The production of ready-mixed concrete shall be such that the operations of placing and finishing will be continuous insofar as the job operations require. The Contractor shall be responsible for producing concrete that will have the required consistency when delivered to the work. Concrete which is unsuitable for placement as delivered will be rejected. The Engineer may require such modification of procedures as will produce satisfactory results.
- (9) **Use of Multiple Plants in the Same Construction Item.** The Contractor may simultaneously use central-mixed, truck-mixed, and shrink-mixed concrete from more than one plant, for the same construction item, on the same day, and in the same pour. However, the following criteria shall be met.
 - a. Each plant shall use the same cement, finely divided minerals, aggregates, admixtures, and fibers.
 - b. Each plant shall use the same mix design. However, material proportions may be altered slightly in the field to meet slump and air content criteria. Field water adjustments shall not result in a difference that exceeds 0.02 between plants for water/cement ratio. The required cement factor for central-mixed concrete shall be increased to match truck-mixed or shrink-mixed concrete, if the latter two types of mixed concrete are used in the same pour.
 - c. The maximum slump difference between deliveries of concrete shall be 3/4 in. (19 mm) when tested at the jobsite. If the difference is exceeded, but test results are within specification limits, the concrete may be used. The Contractor shall take immediate corrective action and shall test subsequent deliveries of concrete until the slump difference is corrected. For each day, the first three truck loads of delivered concrete from each plant shall be tested for slump by the Contractor. Thereafter, when a specified test frequency for slump is to be performed, it shall be conducted for each plant at the same time.
 - d. The maximum air content difference between deliveries of concrete shall be 1.5 percent when tested at the jobsite. If the difference is exceeded, but test results are within specification limits, the concrete may be used. The Contractor shall take immediate corrective action and shall test subsequent deliveries of concrete until the air content difference is corrected. For each day, the first three truck loads of delivered concrete from each plant shall be tested for air content by the Contractor. Thereafter, when a specified test frequency for air content is to be performed, it shall be conducted for each plant at the same time.

- e. Strength tests shall be performed and taken at the jobsite for each plant. When a specified strength test is to be performed, it shall be conducted for each plant at the same time. The difference between plants for their mean strength shall not exceed 450 psi (3100 kPa) compressive and 80 psi (550 kPa) flexural. The strength standard deviation for each plant shall not exceed 650 psi (4480 kPa) compressive and 110 psi (760 kPa) flexural. The mean and standard deviation requirements shall apply to the test of record. If the strength difference requirements are exceeded, the Contractor shall take corrective action.
 - f. The maximum haul time difference between deliveries of concrete shall be 15 minutes. If the difference is exceeded, but haul time is within specification limits, the concrete may be used. The Contractor shall take immediate corrective action and check subsequent deliveries of concrete until the haul time difference is corrected.
- (b) Class PC Concrete. The concrete shall be central-mixed or truck mixed. Variations in plastic concrete properties shall be minimized between batches, and shall include having the truck mixer discharge all wash water prior to batching the concrete materials or receiving concrete from a stationary mixer.
- (c) Class PV Concrete. The concrete shall be central-mixed or truck mixed.

The required mixing time for stationary mixers with a capacity greater than 2 cu yd (1.5 cu m) may be less than 75 seconds upon satisfactory completion of a mixer performance test. Mixer performance tests may be requested by the Contractor when the quantity of concrete to be placed exceeds 50,000 sq yd (42,000 sq m). The testing shall be conducted according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Field Test Procedures for Mixer Performance and Concrete Uniformity Tests".

The Contractor will be allowed to test two mixing times within a range of 50 to 75 seconds. If satisfactory results are not obtained from the required tests, the mixing time shall continue to be 75 seconds for the remainder of the contract. If satisfactory results are obtained, the acceptable mixing time may be reduced for those particular circumstances to the mixing time which test results indicate to provide satisfactory mixing. In no event will mixing time be less than 50 seconds.

No additional compensation will be allowed the Contractor for any delays or inconveniences if the Contractor elects to change the mixing time. The Contractor shall furnish the labor, equipment, and material required to perform the testing according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Field Test Procedures for Mixer Performance and Concrete Uniformity Tests", at no additional cost to the Department.

A contract which has 12 ft (3.6 m) wide pavement or base course, and a continuous length of 1/2 mile (0.8 km) or more, shall have the following additional requirements.

- (1) The plant and truck delivery operation shall be able to provide a minimum of 50 cu yd (38 cu m) of concrete per hour.
- (2) The truck mixer shall discharge all wash water prior to batching the concrete materials.
- (3) The plant shall have automatic or semi-automatic batching equipment.
- (d) All Other Classes of Concrete. The concrete shall be central-mixed, truck mixed, or shrink mixed concrete.

1020.12 Mobile Portland Cement Concrete Plants. The use of a mobile portland cement concrete plant may be approved under the provisions of Article 1020.10 for volumetric proportioning in small isolated structures, thin overlays, and for miscellaneous and incidental concrete items.

The first 1 cu ft (0.03 cu m) of concrete produced may not contain sufficient mortar and shall not be incorporated in the work. The side plate on the cement feeder shall be removed periodically (normally the first time the mixer is used each day) to see if cement is building up on the feed drum.

Sufficient mixing capacity of mixers shall be provided to enable continuous placing and finishing insofar as the job operations and the specifications require.

Slump and air tests made immediately after discharge of the mix may be misleading, since the aggregates may absorb a significant amount of water for four or five minutes after mixing.

1020.13 Curing and Protection. The methods of curing and protection and the length of the curing period vary somewhat, depending on the type of construction involved. A ready reference for the method of curing, curing period, and method of protection for each of the various types of concrete construction is included in the following Index Table.

INDEX TABLE OF CURING AND PROTECTION OF CONCRETE CONSTRUCTION			
TYPE OF CONSTRUCTION	CURING METHODS	CURING PERIOD DAYS	LOW AIR TEMPERATURE PROTECTION METHODS
Cast-in-Place Concrete ^{11/}			
Pavement Shoulder	1020.13(a)(1)(2)(3)(4)(5) ^{3/ 5/}	3	1020.13(c)
Base Course			
Base Course Widening	1020.13(a)(1)(2)(3)(4)(5) ^{2/}	3	1020.13(c)
Driveway			
Median			
Barrier			
Curb			
Gutter	1020.13(a)(1)(2)(3)(4)(5) ^{4/ 5/}	3	1020.13(c) ^{16/}
Curb & Gutter			
Sidewalk			
Slope Wall			
Paved Ditch			
Catch Basin			
Manhole	1020.13(a)(1)(2)(3)(4)(5) ^{4/}	3	1020.13(c)
Inlet			
Valve Vault			
Pavement Patching	1020.13(a)(1)(2)(3)(4)(5) ^{2/}	3 ^{12/}	1020.13(c)
Railroad Crossing	1020.13(a)(3)(5)	1	1020.13(c)
Piles and Drilled Shafts	1020.13(a)(3)(5)	7	1020.13(d)(1)(2)(3)
Foundations & Footings			
Seal Coat	1020.13(a)(1)(2)(3)(4)(5) ^{4/ 6/}	7	1020.13(d)(1)(2)(3)
Substructure	1020.13(a)(1)(2)(3)(4)(5) ^{1/ 7/}	7	1020.13(d)(1)(2)(3)
Superstructure (except deck)	1020.13(a)(1)(2)(3)(5) ^{B/}	7	1020.13(d)(1)(2)
Deck	1020.13(a)(5)	7	1020.13(d)(1)(2) ^{17/}
Retaining Walls	1020.13(a)(1)(2)(3)(4)(5) ^{1/ 7/}	7	1020.13(d)(1)(2)
Pump Houses	1020.13(a)(1)(2)(3)(4)(5) ^{1/}	7	1020.13(d)(1)(2)
Culverts	1020.13(a)(1)(2)(3)(4)(5) ^{4/ 6/}	7	1020.13(d)(1)(2) ^{18/}
Other Incidental Concrete	1020.13(a)(1)(2)(3)(5)	3	1020.13(c)
Precast Concrete ^{11/}			
Bridge Slabs			
Piles and Pile Caps	1020.13(a)(3)(5) ^{9/ 10/}	As ^{13/}	9/
Other Structural Members		Required	
All Other Precast Items	1020.13(a)(3)(4)(5) ^{2/ 9/ 10/}	As ^{14/}	9/
		Required	
Precast, Prestressed Concrete ^{11/}			
All Items	1020(a)(3)(5) ^{9/ 10/}	Until Strand Tensioning is Released ^{15/}	9/

Notes-General:

1/ Type I, membrane curing only

2/ Type II, membrane curing only

3/ Type III, membrane curing only

- 4/ Type I, II and III membrane curing
- 5/ Membrane Curing will not be permitted between November 1 and April 15.
- 6/ The use of water to inundate foundations and footings, seal coats or the bottom slab of culverts is permissible when approved by the Engineer, provided the water temperature can be maintained at 45 °F (7 °C) or higher.
- 7/ Asphalt emulsion for waterproofing may be used in lieu of other curing methods when specified and permitted according to Article 503.18.
- 8/ On non-traffic surfaces which receive protective coat according to Article 503.19, a linseed oil emulsion curing compound may be used as a substitute for protective coat and other curing methods. The linseed oil emulsion curing compound will be permitted between April 16 and October 31 of the same year, provided it is applied with a mechanical sprayer according to Article 1101.09(b).
- 9/ Steam, supplemental heat, or insulated blankets (with or without steam/supplemental heat) are acceptable and shall be according to the Bureau of Materials and Physical Research's Policy Memorandum "Quality Control/Quality Assurance Program for Precast Concrete Products" and the "Manual for Fabrication of Precast, Prestressed Concrete Products".
- 10/ A moist room according to AASHTO M 201 is acceptable for curing.
- 11/ If curing is required and interrupted because of form removal for cast-in-place concrete items, precast concrete products, or precast prestressed concrete products, the curing shall be resumed within two hours from the start of the form removal.
- 12/ Curing maintained only until opening strength is attained, with a maximum curing period of three days.
- 13/ The curing period shall end when the concrete has attained the mix design strength. The producer has the option to discontinue curing when the concrete has attained 80 percent of the mix design strength or after seven days. All strength test specimens shall remain with the units and shall be subjected to the same curing method and environmental condition as the units, until the time of testing.
- 14/ The producer shall determine the curing period or may elect to not cure the product. All strength test specimens shall remain with the units and shall be subjected to the same curing method and environmental condition as the units, until the time of testing.
- 15/ The producer has the option to continue curing after strand release.

- 16/ When structural steel or structural concrete is in place above slope wall, Article 1020.13(c) shall not apply. The protection method shall be according to Article 1020.13(d)(1).
- 17/ When Article 1020.13(d)(2) is used to protect the deck, the housing may enclose only the bottom and sides. The top surface shall be protected according to Article 1020.13(d)(1).
- 18/ For culverts having a waterway opening of 10 sq ft (1 sq m) or less, the culverts may be protected according to Article 1020.13(d)(3).
- (a) Methods of Curing. Except as provided for in the Index Table of Curing and Protection of Concrete Construction, curing shall be accomplished by one of the following described methods. When water is required to wet the surface, it shall be applied as a fine spray so that it will not mar or pond on the surface. Except where otherwise specified, the curing period shall be at least 72 hours.
- (1) Waterproof Paper Method. The surface of the concrete shall be covered with waterproof paper as soon as the concrete has hardened sufficiently to prevent marring the surface. The surface of the concrete shall be wetted immediately before the paper is placed. The blankets shall be lapped at least 12 in. (300 mm) end to end, and these laps shall be securely weighted with a windrow of earth, or other approved method, to form a closed joint. The same requirements shall apply to the longitudinal laps where separate strips are used for curing edges, except the lap shall be at least 9 in. (225 mm). The edges of the blanket shall be weighted securely with a continuous windrow of earth or any other means satisfactory to the Engineer to provide an air-tight cover. Any torn places or holes in the paper shall be repaired immediately by patches cemented over the openings, using a bituminous cement having a melting point of not less than 180 °F (82 °C). The blankets may be reused, provided they are air-tight and kept serviceable by proper repairs.
- A longitudinal pleat shall be provided in the blanket to permit shrinkage where the width of the blanket is sufficient to cover the entire surface. The pleat will not be required where separate strips are used for the edges. Joints in the blanket shall be sewn or cemented together in such a manner that they will not separate during use.
- (2) Polyethylene Sheeting Method. The surface of the concrete shall be covered with white polyethylene sheeting as soon as the concrete has hardened sufficiently to prevent marring the surface. The surface of the concrete shall be wetted immediately before the sheeting is placed. The edges of the sheeting shall be weighted securely with a continuous windrow of earth or any other means satisfactory to the Engineer to provide an air-tight cover. Adjoining sheets shall overlap not less than 12 in. (300 mm) and the laps shall be securely weighted with earth, or any other means satisfactory to the Engineer, to provide an air tight cover. For portland cement concrete surface and base course, the polyethylene sheets shall be not less than 100 ft (30 m) in length nor

longer than can be conveniently handled, and shall be of such width that, when in place, they will cover the full width of the surface, including the edges, except that separate strips may be used to cover the edges. Any tears or holes in the sheeting shall be repaired. When sheets are no longer serviceable as a single unit, the Contractor may select from such sheets and reuse those which will serve for further applications, provided two sheets are used as a single unit; however, the double sheet units will be rejected when the Engineer deems that they no longer provide an air tight cover.

- (3) Wetted Burlap Method. The surface of the concrete shall be covered with wetted burlap blankets as soon as the concrete has hardened sufficiently to prevent marring the surface. The blankets shall overlap 6 in. (150 mm). At least two layers of wetted burlap shall be placed on the finished surface. The burlap shall be kept saturated by means of a mechanically operated sprinkling system. In place of the sprinkling system, at the Contractor's option, two layers of burlap covered with impermeable covering shall be used. The burlap shall be kept saturated with water. Plastic coated burlap may be substituted for one layer of burlap and impermeable covering.

The blankets shall be placed so that they are in contact with the edges of the concrete, and that portion of the material in contact with the edges shall be kept saturated with water.

- (4) Membrane Curing Method. Membrane curing will not be permitted where a protective coat, concrete sealer, or waterproofing is to be applied, or at areas where rubbing or a normal finish is required, or at construction joints other than those necessary in pavement or base course. Concrete at these locations shall be cured by another method specified in Article 1020.13(a) at no additional cost to the Department.

After the concrete has been finished and immediately after the water sheen has disappeared from the surface of the concrete, the surface shall be sealed with membrane curing compound of the type specified. The seal shall be maintained for the specified curing period. The edges of the concrete shall, likewise, be sealed immediately after the forms are removed. Two separate applications, applied at least one minute apart, each at the rate of not less than 1 gal/250 sq ft (0.16 L/sq m) will be required upon the surfaces and edges of the concrete. These applications shall be made with the mechanical equipment specified. Type III compound shall be agitated immediately before and during the application.

At locations where the coating is discontinuous or where pin holes show or where the coating is damaged due to any cause and on areas adjacent to sawed joints, immediately after sawing is completed, an additional coating of membrane curing compound shall be applied at the above specified rate. The equipment used may be of the same type as that used for coating variable widths of pavement. Before the additional coating is applied adjacent to sawed joints, the cut faces of the joint shall be protected by inserting a suitable flexible material in the joint, or

placing an adhesive width of impermeable material over the joint, or by placing the permanent sealing compound in the joint. Material, other than the permanent sealing compound, used to protect cut faces of the joint, shall remain in place for the duration of the curing period. In lieu of applying the additional coating, the area of the sawed joint may be cured according to any other method permitted.

When rain occurs before an application of membrane curing compound has dried, and the coating is damaged, the Engineer may require another application be made in the same manner and at the same rate as the original coat. The Engineer may order curing by another method specified, if unsatisfactory results are obtained with membrane curing compound.

- (5) Wetted Cotton Mat Method. After the surface of concrete has been textured or finished, it shall be covered immediately with dry or damp cotton mats. The cotton mats shall be placed in a manner which will not mar the concrete surface. A texture resulting from the cotton mat material is acceptable. The cotton mats shall then be wetted immediately and thoroughly soaked with a gentle spray of water. For bridge decks, a foot bridge shall be used to place and wet the cotton mats.

The cotton mats shall be maintained in a wetted condition until the concrete has hardened sufficiently to place soaker hoses without marring the concrete surface. The soaker hoses shall be placed on top of the cotton mats at a maximum 4 ft (1.2 m) spacing. The cotton mats shall be kept wet with a continuous supply of water for the remainder of the curing period. Other continuous wetting systems may be used if approved by the Engineer.

After placement of the soaker hoses, the cotton mats shall be covered with white polyethylene sheeting or burlap-polyethylene blankets.

For construction items other than bridge decks, soaker hoses or a continuous wetting system will not be required if the alternative method keeps the cotton mats wet. Periodic wetting of the cotton mats is acceptable.

For areas inaccessible to the cotton mats on bridge decks, curing shall be according to Article 1020.13(a)(3).

- (b) Removing and Replacing Curing Covering. When curing methods specified above in Article 1020.13(a), (1), (2), or (3) are used for portland cement concrete pavement, the curing covering for each day's paving shall be removed to permit testing of the pavement surface with a profilograph or straightedge, as directed by the Engineer.

Immediately after testing, the surface of the pavement shall be wetted thoroughly and the curing coverings replaced. The top surface and the edges of the concrete shall not be left unprotected for a period of more than 1/2 hour.

- (c) Protection of Portland Cement Concrete, Other Than Structures, From Low Air Temperatures. When the official National Weather Service forecast for the construction area predicts a low of 32 °F (0 °C), or lower, or if the actual temperature drops to 32 °F (0 °C), or lower, concrete less than 72 hours old shall be provided at least the following protection.

Minimum Temperature	Protection
25 – 32 °F (-4 – 0 °C)	Two layers of polyethylene sheeting, one layer of polyethylene and one layer of burlap, or two layers of waterproof paper.
Below 25 °F (-4 °C)	6 in. (150 mm) of straw covered with one layer of polyethylene sheeting or waterproof paper.

These protective covers shall remain in place until the concrete is at least 96 hours old. When straw is required on pavement cured with membrane curing compound, the compound shall be covered with a layer of burlap, polyethylene sheeting or waterproof paper before the straw is applied.

After September 15, there shall be available to the work within four hours, sufficient clean, dry straw to cover at least two days production of the mixer. Additional straw shall be provided as needed to afford the protection required. Regardless of the precautions taken, the Contractor shall be responsible for protection of the concrete placed and any concrete damaged by cold temperatures shall be removed and replaced.

- (d) Protection of Portland Cement Concrete Structures From Low Air Temperatures. When the official National Weather Service forecast for the construction area predicts a low below 45 °F (7 °C), or if the actual temperature drops below 45 °F (7 °C), concrete less than 72 hours old shall be provided protection. Concrete shall also be provided protection when placed during the winter period of December 1 through March 15. Concrete shall not be placed until the materials, facilities, and equipment for protection are approved by the Engineer.

When directed by the Engineer, the Contractor may be required to place concrete during the winter period. When winter construction is specified, the Contractor shall proceed with the construction, including excavation, pile driving, concrete, steel erection, and all appurtenant work required for the complete construction of the item, except at times when weather conditions make such operations impracticable.

Regardless of the precautions taken, the Contractor shall be responsible for protection of the concrete placed and any concrete damaged by cold temperatures shall be removed and replaced.

- (1) Protection Method I. The concrete shall be completely covered with insulating material such as fiberglass, rock wool, or other approved commercial insulating material having the minimum thermal resistance R, as defined in ASTM C 168, for the corresponding minimum

dimension of the concrete unit being protected as shown in the following table.

Minimum Pour Dimension		Thermal Resistance R
in.	(mm)	
6 or less	(150 or less)	R=16
> 6 to 12	(> 150 to 300)	R=10
> 12 to 18	(> 300 to 450)	R=6
> 18	(> 450)	R=4

The insulating material manufacturer shall clearly mark the insulating material with the thermal resistance R value.

The insulating material shall be completely enclosed on sides and edges with an approved waterproof liner and shall be maintained in a serviceable condition. Any tears in the liner shall be repaired in a manner approved by the Engineer. The Contractor shall provide means for checking the temperature of the surface of the concrete during the protection period.

On formed surfaces, the insulating material shall be attached to the outside of the forms with wood cleats or other suitable means to prevent any circulation of air under the insulation and shall be in place before the concrete is placed. The blanket insulation shall be applied tightly against the forms. The edges and ends shall be attached so as to exclude air and moisture. If the blankets are provided with nailing flanges, the flanges shall be attached to the studs with cleats. Where tie rods or reinforcement bars protrude, the areas adjacent to the rods or bars shall be adequately protected in a manner satisfactory to the Engineer. Where practicable, the insulation shall overlap any previously placed concrete by at least 1 ft (300 mm). Insulation on the underside of floors on steel members shall cover the top flanges of supporting members. On horizontal surfaces, the insulating material shall be placed as soon as the concrete has set, so that the surface will not be marred and shall be covered with canvas or other waterproof covering. The insulating material shall remain in place for a period of seven days after the concrete is placed.

The Contractor may remove the forms, providing the temperature is 35 °F (2 °C) and rising and the Contractor is able to wrap the particular section within two hours from the time of the start of the form removal. The insulation shall remain in place for the remainder of the seven days curing period.

- (2) Protection Method II. The concrete shall be enclosed in adequate housing and the air surrounding the concrete kept at a temperature of not less than 50 °F (10 °C) nor more than 80 °F (27 °C) for a period of seven days after the concrete is placed. The Contractor shall provide means for checking the temperature of the surface of the concrete or air temperature within the housing during the protection period. All

exposed surfaces within the housing shall be cured according to the Index Table.

The Contractor shall provide adequate fire protection where heating is in progress and such protection shall be accessible at all times. The Contractor shall maintain labor to keep the heating equipment in continuous operation.

At the close of the heating period, the temperature shall be decreased to the approximate temperature of the outside air at a rate not to exceed 15 °F (8 °C) per 12 hour period, after which the housing may be removed. The surface of the concrete shall be permitted to dry during the cooling period.

- (3) Protection Method III. As soon as the surface is sufficiently set to prevent marring, the concrete shall be covered with 12 in. (300 mm) of loose, dry straw followed by a layer of impermeable covering. The edges of the covering shall be sealed to prevent circulation of air and prevent the cover from flapping or blowing. The protection shall remain in place until the concrete is seven days old. If construction operations require removal, the protection removed shall be replaced immediately after completion or suspension of such operations.

1020.14 Temperature Control for Placement. Temperature control for concrete placement shall be according to the following.

- (a) Concrete other than Structures. Concrete may be placed when the air temperature is above 35 °F (2 °C) and rising, and concrete placement shall stop when the falling temperature reaches 40 °F (4 °C) or below, unless otherwise approved by the Engineer.

The temperature of concrete immediately before placement, shall be a minimum of 50 °F (10 °C) and a maximum of 90 °F (32 °C). Plastic concrete temperatures up to 96 °F (35 °C), as placed, may be permitted, provided jobsite conditions permit placement and finishing without excessive use of water on and/or overworking of the surface. The occurrence within 24 hours of unusual surface distress shall be cause to revert to a maximum 90 °F (32 °C) plastic concrete temperature.

- (b) Concrete in Structures. Concrete may be placed when the air temperature is above 40 °F (4 °C) and rising, and concrete placement shall stop when the falling temperature reaches 45 °F (7 °C) or below, unless otherwise approved by the Engineer.

The temperature of the concrete as placed in the forms shall be a minimum of 50 °F (10 °C) and a maximum of 90 °F (32 °C). When insulated forms are used, the maximum temperature of the concrete mixture shall be 80 °F (25 °C). If the Engineer determines that heat of hydration might cause excessive temperatures in the concrete, the concrete shall be placed at a temperature between 50 °F (10 °C) and 60 °F (15 °C), as per the Engineer's instructions. When concrete is placed in contact with previously placed

concrete, the temperature of the mixed concrete may be increased as required to offset anticipated heat loss.

- (c) All Classes of Concrete. Aggregates and water shall be heated or cooled as necessary to produce concrete within the specified temperature limits.

When placing of concrete is authorized during cold weather, the Engineer may require the water and/or the aggregates to be heated to a minimum of 70 °F (20 °C) and a maximum of 150 °F (65 °C). The aggregates may be heated by either steam or dry heat prior to being placed in the mixer. The apparatus used shall heat the mass uniformly and shall be so arranged as to preclude the possible occurrence of overheated areas which might damage the materials. No frozen aggregates shall be used in the concrete.

- (d) Temperature. The concrete temperature shall be determined according to Illinois Modified AASHTO T 309.

SECTION 1021. CONCRETE ADMIXTURES

1021.01 General. Admixtures shall be furnished in liquid form ready for use. The admixtures shall be delivered in the manufacturer's original containers, bulk tank trucks or such containers or tanks as are acceptable to the Engineer. Delivery shall be accompanied by a ticket which clearly identifies the manufacturer and trade name of the material. Containers shall be readily identifiable as to manufacturer and trade name of the material they contain.

Corrosion inhibitors will be maintained on the Department's Approved List of Corrosion Inhibitors. All other concrete admixture products will be maintained on the Department's Approved List of Concrete Admixtures. For the admixture submittal, a report prepared by an independent laboratory accredited by the AASHTO Materials Reference Laboratory (AMRL) for Portland Cement Concrete shall be provided. The report shall show the results of physical tests conducted no more than five years prior to the time of submittal, according to applicable specifications. However, for corrosion inhibitors the ASTM G 109 test information specified in ASTM C 1582 is not required to be from an independent lab. All other information in ASTM C 1582 shall be from an independent lab.

Tests shall be conducted using materials and methods specified on a "test" concrete and a "reference" concrete, together with a certification that no changes have been made in the formulation of the material since the performance of the tests. Per the manufacturer's option, the cement content for all required tests shall either be according to applicable specifications or 5.65 cwt/cu yd (335 kg/cu m). Compressive strength test results for six months and one year will not be required.

Prior to the approval of an admixture, the Engineer reserves the right to request a sample for testing. The test and reference concrete mixtures tested by the Engineer will contain a cement content of 5.65 cwt/cu yd (335 kg/cu m). For freeze-thaw testing, the Department will perform the test according to Illinois Modified AASHTO T 161, Procedure B. The flexural strength test will be performed according to AASHTO T 177. If the Engineer decides to test the admixture, the manufacturer shall submit AASHTO T 197 water content and set time test results on the standard

cement used by the Department. The test and reference concrete mixture shall contain a cement content of 5.65 cwt/cu yd (335 kg/cu m). The manufacturer may select their lab or an independent lab to perform this testing. The laboratory is not required to be accredited by AASHTO.

The manufacturer shall include in the submittal the following information: the manufacturing range for specific gravity, the midpoint and manufacturing range for residue by oven drying, and manufacturing range of pH. The submittal shall also include an infrared spectrophotometer trace no more than five years old. If an accelerating admixture according to Article 1020.04 contains calcium salts, the midpoint and manufacturing range for residue by oven drying will not be required.

For air-entraining admixtures according to Article 1021.02, the specific gravity allowable manufacturing range shall be established by the manufacturer and the test method shall be according to ASTM C 494. For residue by oven drying and pH, the allowable manufacturing range and test methods shall be according to ASTM C 260.

For admixtures according to Articles 1021.03, 1021.04, 1021.05, 1021.06, and 1021.07, the pH allowable manufacturing range shall be established by the manufacturer and the test method shall be according to ASTM E 70. For specific gravity and residue by oven drying, the allowable manufacturing range and test methods shall be according to ASTM C 494.

When test results are more than seven years old, the manufacturer shall re-submit the infrared spectrophotometer trace and the report prepared by an independent laboratory accredited by AASHTO.

All admixtures, except chloride-based accelerators, shall contain a maximum of 0.3 percent chloride by weight (mass) as determined by an appropriate test method selected by the manufacturer. To verify the manufacturer test result, the Department will use Illinois Modified AASHTO T 260, Procedure A, Method 1.

Random field samples may be taken by the Department to verify an admixture meets specification. A split sample will be provided to the manufacturer if requested. Admixtures that do not meet specification requirements or an allowable manufacturing range established by the manufacturer shall be replaced with new material.

1021.02 Air-Entraining Admixtures. Air-entraining admixtures shall be according to AASHTO M 154.

1021.03 Retarding and Water-Reducing Admixtures. The admixture shall be according to the following.

- (a) The retarding admixture shall be according to AASHTO M 194, Type B (retarding) or Type D (water-reducing and retarding).
- (b) The water-reducing admixture shall be according to AASHTO M 194, Type A.

- (c) The high range water-reducing admixture shall be according to AASHTO M 194, Type F (high range water-reducing) or Type G (high range water-reducing and retarding).

1021.04 Accelerating Admixtures. The admixture shall be according to AASHTO M 194, Type C (accelerating) or Type E (water reducing and accelerating).

1021.05 Self-Consolidating Admixtures. The self-consolidating admixture system shall consist of either a high range water-reducing admixture only or a high range water-reducing admixture combined with a separate viscosity modifying admixture. The one or two component admixture system shall be capable of producing a concrete that can flow around reinforcement and consolidate under its own weight without additional effort and without segregation.

The high range water-reducing admixture shall be according to AASHTO M 194, Type F.

The viscosity modifying admixture shall be according to ASTM C 494, Type S (specific performance).

1021.06 Rheology-Controlling Admixture. The rheology-controlling admixture shall be capable of producing a concrete mixture with a lower yield stress that will consolidate easier for slipform applications used by the Contractor. The rheology-controlling admixture shall be according to ASTM C 494, Type S (specific performance).

1021.07 Corrosion Inhibitor. The corrosion inhibitor shall be according to one of the following.

- (a) Calcium Nitrite. The corrosion inhibitor shall contain a minimum 30 percent calcium nitrite by weight (mass) of solution, and shall comply with either the requirements of AASHTO M 194, Type C (accelerating) or the requirements of ASTM C 1582. The corrosion inhibiting performance requirements of ASTM C 1582 shall not apply.
- (b) Other Materials. The corrosion inhibitor shall be according to ASTM C 1582.

SECTION 1022. CONCRETE CURING MATERIALS

1022.01 Membrane Curing Compounds. Membrane curing compounds shall be according to AASHTO M 148 (ASTM C 309) and the following.

The manufacturer shall provide the membrane curing compound manufacturing range for specific gravity and non-volatile content.

The material will be sampled at the manufacturer's plant by an authorized representative of the Department. The Engineer will test the sampled material and no material shall be used until it has been approved.

Each container shall be legibly marked with the name of the manufacturer, the type (IDOT designation) or type/class (ASTM designation), the manufacturer's batch or lot number, date of manufacture, and the Department's test identification number.

Approved material shall not be used after nine months from the date of manufacture, unless sampled and tested for re-approval by the Engineer. Material more than 18 months old from the date of manufacture shall not be used.

Based on information provided in the material safety data sheet, the Engineer reserves the right to reject the material due to health or safety concerns.

Specimens used for determining moisture loss will be made and tested according to Illinois Modified AASHTO T 155.

The membrane curing compound types shall be as follows.

- (a) Type I. This material shall be according to AASHTO M 148 (ASTM C 309, Type I, Class A). It shall be clear or translucent, without dye, and there are no restrictions on dissolved solids.
- (b) Type II. This material shall be according to AASHTO M 148 (ASTM C 309, Type 1-D, Class B). It shall be clear or translucent, with fugitive dye, and it shall not contain materials which may prevent bonding of hot-mix asphalt to concrete surfaces.
- (c) Type III. This material shall be according to AASHTO M 148 (ASTM C 309, Type 2, Class A). It shall be white pigmented and there are no restrictions on dissolved solids.
- (d) Linseed Oil Emulsion. This material, which performs as a curing compound and sealer, shall be a blend of boiled linseed oil and high viscosity, heavy bodied linseed oil, emulsified in a water solution.

The oil phase shall be 50 ± 4 percent by volume and shall consist of boiled linseed oil according to ASTM D 260. The water phase shall be 50 ± 4 percent by volume. The Engineer will verify the oil and water phases according to the Illinois Laboratory Test Procedure "Linseed Oil Based Emulsion Curing Compound".

The emulsion shall also meet the requirements of a Type I curing compound as described in (a) above, except the drying time requirement will be waived.

1022.02 Burlap Curing Blankets and Cotton Mats. These materials shall be according to AASHTO M 182 and shall be free from substances which may be deleterious to freshly placed concrete. Burlap shall meet the requirements for Class 3.

Blankets and mats shall be in a condition satisfactory to the Engineer. Any tears or holes shall be repaired.

1022.03 Waterproof Paper Blankets, White Polyethylene Sheeting, and Burlap-Polyethylene Blankets. These materials shall be white and according to

AASHTO M 171, except moisture loss test specimens shall be made according to Illinois Modified AASHTO T 155.

Blankets and sheeting shall be in a condition satisfactory to the Engineer. Any tears or holes shall be repaired.

SECTION 1023. PROTECTIVE COAT

1023.01 Requirements. Protective coat shall meet the requirements of AASHTO M 233 (boiled linseed oil), except the protective coat shall have a nonvolatile range of 53 to 57 percent and the petroleum spirits used in the production of the protective coat shall be Type I meeting the requirements of ASTM D 235 with a maximum copper corrosion rating of 2.

SECTION 1024. GROUT AND NONSHRINK GROUT

1024.01 Requirements for Grout. The grout shall be thoroughly mixed, and shall have a minimum temperature of 50 °F (10 °C). Water shall not exceed the minimum needed for placement and finishing.

Materials for the grout shall be according to the following.

Item	Article/Section
(a) Cement	1001
(b) Water	1002
(c) Fine Aggregate	1003.02
(d) Fly Ash	1010.01, 1010.02
(e) Concrete Admixtures	1021

1024.02 Requirements for Nonshrink Grout. The prepackaged product shall be mixed and placed according to the manufacturer's instructions, except the addition of aggregate to the prepackaged product will not be permitted. Water shall not exceed the minimum needed for placement and finishing.

Item	Article/Section
(a) Nonshrink Grout (Note 1)	
(b) Water	1002

Note 1. Nonshrink grout shall be according to Illinois Modified ASTM C 1107.

SECTION 1025. EPOXY CONCRETE MATERIALS

1025.01 Epoxy Bonding Compound. The epoxy bonding compound shall be according to ASTM C 881, Type IV, Grade 1, Class A, B, or C. The class supplied shall be governed by the range of temperature for which the material is to be used.

SECTION 1026. CONCRETE SEALER

1026.01 General. Sealer types shall be according to the listing in AASHTO M 224 and additional types will be considered for use. The sealer shall be listed on the Department's approved list for concrete sealers.

The sealer shall have a clear or amber color when dry.

The manufacturer shall provide an infrared spectrophotometer trace of the concrete sealer.

The sealer will be tested by the Department according to Illinois Modified ASTM C 672. The average visual rating of the test specimens treated with sealer, divided by, the average visual rating of the untreated test specimens shall not exceed 0.80 after 60 cycles. In addition, the sealer shall not be debonded from the test specimens upon completion of testing.

SECTION 1027. CHEMICAL ADHESIVE

1027.01 Chemical Adhesive Resin System. The chemical adhesive resin system shall consist of a two part, fast-setting resin and filler/hardener. The system shall meet the requirements of the Illinois Test Procedure for Chemical Adhesives and be listed on the Department's approved list for Chemical Adhesives.

SECTION 1028. FABRIC REINFORCED ELASTOMERIC

1028.01 Fabric Reinforced Elastomeric. Fabric reinforced elastomeric shall consist of a fabric and an elastomer compound.

The elastomer compound shall be according to Table X1 of AASHTO M 251 for Polychloroprene having a minimum Hardness (Durometer) of 50. The composite of the fabric and elastomer compound shall have a minimum tensile strength of 700 x 700 lb/in. (122.6 x 122.6 N/mm) according to ASTM D 378. The minimum elongation at ultimate tensile strength shall be 30 percent according to ASTM D 412.

The minimum thickness of the fabric reinforced elastomeric shall be 1/8 in. (3 mm).

ASPHALT AND BITUMINOUS ITEMS**SECTION 1030. HOT-MIX ASPHALT**

1030.01 Description. This section describes the materials, mix design, quality control/quality assurance (QC/QA), proportioning, mixing, and transportation requirements to produce hot-mix asphalt (HMA) using Illinois Modified Strategic Highway Research Program (SHRP) Superpave criteria.

For simplicity of text, the following HMA nomenclature applies to this Section.

High ESAL	IL-25.0 binder; IL-19.0 binder; IL-12.5 surface; IL-9.5 surface
Low ESAL	IL-19.0L binder; IL-9.5L surface
All Other	Stabilized Subbase (HMA), HMA Shoulders

1030.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate	1004.03
(b) Fine Aggregate (Note 1)	1003.03
(c) RAP Material	1031
(d) Mineral Filler	1011
(e) Hydrated Lime	1012.01
(f) Slaked Quicklime (Note 2)	
(g) Performance Graded Asphalt Binder	1032

Note 1. FA/FM 20 manufactured sand may be required to meet the design requirements. For mixtures with an Ndesign ≥ 90 and for mixture IL-4.75, at least 50 percent of the required fine aggregate fraction shall consist of either stone sand, slag sand, or steel slag meeting the FA/FM 20 gradation.

Note 2. Slaked quicklime shall be according to ASTM C 5.

1030.03 Equipment. Equipment shall be according to the following.

Item	Article/Section
(a) Hot-Mix Asphalt Plant	1102.01
(b) Heating Equipment (Note 1)	1102.07
(c) Hot-Mix Surge Bins	1102.01(a)(6)

Note 1. The asphalt binder shall be transferred to the asphalt tanks and brought to a temperature of 250 to 350 °F (120 to 180 °C). If, at anytime, the asphalt binder temperature exceeds 350 °F (180 °C), the asphalt binder shall not be used. Polymer modified asphalt binder, when specified, shall be shipped, maintained, and stored at the mix plant according to the manufacturer's requirements. Polymer modified asphalt binder shall be placed in an empty tank and shall not be blended with other asphalt binders.

1030.04 Mixture Design. The Contractor shall submit designs for each required mixture. The mixture design shall be performed at a HMA mix design laboratory according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Minimum Private Laboratory Requirements for Construction Materials Testing or Mix Design". Each design shall be verified and approved by the Department as detailed in the current Quality Control/Quality Assurance document "Hot-Mix Asphalt Design Verification Procedure". In no case will a mix design be verified until determination of the apparent low bidder.

When specified on the plans, RAP material meeting the requirements of Section 1031 may be used. The Engineer reserves the right to adjust the quantities of RAP material contained in the mixture for the purpose of mix design or field production, on the basis of test results.

The HMA mixtures shall be designed according to the respective Illinois Modified AASHTO references listed below.

AASHTO M 323	Standard Specification for Superpave Volumetric Mix Design
AASHTO R 30	Standard Practice for Mixture Conditioning of Hot-Mix Asphalt (HMA)
AASHTO R 35	Standard Practice for Superpave Volumetric Design for Hot-Mix Asphalt (HMA)
AASHTO T 209	Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
AASHTO T 305	Standard Method of Test for Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures
AASHTO T 312	Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
AASHTO T 308	Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method

- (a) **Mixture Composition.** The Job Mix Formula (mix design) represents the aggregate grading and asphalt binder content that produce the desired mix criteria in the laboratory. The ingredients of the HMA shall be combined in such proportions as to produce a mixture conforming to the composition limits by weight.

For all HMA mixtures, it is recommended that the selected combined aggregate gradation not pass through the restricted zones specified in Illinois Modified AASHTO M 323.

- (1) High ESAL Mixtures. The Job Mix Formula (JMF) shall fall within the following limits.

High ESAL, MIXTURE COMPOSITION (% PASSING) ^{1/}								
Sieve Size	IL-25.0 mm		IL-19.0 mm		IL-12.5 mm		IL-9.5 mm	
	min	max	min	max	min	max	min	max
1 1/2 in. (37.5 mm)		100						
1 in. (25 mm)	90	100		100				
3/4 in. (19 mm)		90	82	100		100		
1/2 in. (12.5 mm)	45	75	50	85	90	100		100
3/8 in. (9.5 mm)						89	90	100
#4 (4.75 mm)	24	42 ^{2/}	24	50 ^{2/}	28	65	28	65
#8 (2.36 mm)	16	31	20	36	28	48 ^{3/}	28	48 ^{3/}
#16 (1.18 mm)	10	22	10	25	10	32	10	32
#50 (300 μm)	4	12	4	12	4	15	4	15
#100 (150 μm)	3	9	3	9	3	10	3	10
#200 (75 μm)	3	6	3	6	4	6	4	6
Ratio Dust/Asphalt Binder		1.0		1.0		1.0		1.0

- 1/ Based on percent of total aggregate weight.
- 2/ The mixture composition shall not exceed 40 percent passing the #4 (4.75 mm) sieve for binder courses with Ndesign ≥ 90.
- 3/ The mixture composition shall not exceed 40 percent passing the #8 (2.36 mm) sieve for surface courses with Ndesign ≥ 90.
- (2) Low ESAL Mixtures. The Job Mix Formula (JMF) shall fall within the following limits.

Low ESAL, MIXTURE COMPOSITION (% PASSING)				
Sieve Size	IL-9.5L		IL-19.0L	
	min.	max.	min.	max.
1 in. (25.0 mm)				100
3/4 in. (19.0 mm)			95	100
1/2 in. (12.5 mm)		100		
3/8 in. (9.5 mm)	95	100		
#4 (4.75 mm)	52	80	38	65
#8 (2.36 mm)	38	65		
#30 (600 µm)		< 50% of the percentage passing the #4		< 50% of the percentage passing the #4
#200 (75 µm)	4.0	8.0	3.0	7.0
Asphalt Binder %	4.0	8.0	4.0	8.0
Ratio Dust/Asphalt Binder		1.0 @ design		1.0 @ design

- (3) All Other Mixtures. The Job Mix Formula (JMF) shall fall within the following limits.

All Other, MIXTURE COMPOSITION, % by Dry Weight			
Without RAP		With RAP	
Virgin Aggregate	93.0 to 96.0	Virgin Aggregate	46.0 to 96.0
		RAP Materials	0 to 50
		Mineral Filler (If required)	0 to 5.0
Asphalt Binder	4.0 to 7.0	Asphalt Binder	4.0 to 7.0
Ratio Dust/Asphalt Binder	1.4 (max)	Ratio Dust/Asphalt Binder	1.4 (max)

- (4) IL-4.75 Mixture. The Job Mix Formula (JMF) shall fall within the following limits.

IL-4.75, MIXTURE COMPOSITION	
Sieve	Percent Passing
1/2 in. (12.5 mm)	100
3/8 in. (9.5 mm)	100
No. 4 (4.75 mm)	90-100
No. 8 (2.36 mm)	70-90
No. 16 (1.18 mm)	50-65
No. 30 (600 µm)	35-55
No. 50 (300 µm)	15-30
No. 100 (150 µm)	10-18
No. 200 (75 µm)	7-9
AB Content	7% to 9%

(b) Volumetric Requirements.

- (1) High ESAL Mixtures. The target value for the air voids of the HMA shall be 4.0 percent at the design number of gyrations. The VMA and VFA of the HMA design shall be based on the nominal maximum size of the aggregate in the mix, and shall conform to the following requirements.

VOLUMETRIC REQUIREMENTS High ESAL					
	Voids in the Mineral Aggregate (VMA), % minimum				Voids Filled with Asphalt Binder (VFA), %
N _{design}	IL-25.0	IL-19.0	IL-12.5	IL-9.5	
50	12.0	13.0	14.0	15	65 - 78
70					65 - 75
90					
105					

- (2) Low ESAL Mixtures.

VOLUMETRIC REQUIREMENTS Low ESAL				
Mixture Composition	Design Compactive Effort	Design Air Voids Target %	VMA (Voids in the Mineral Aggregate), % min.	VFA (Voids Filled with Asphalt Binder), %
IL-9.5L	N _{DES} =30	4.0	15.0	65-78
IL-19.0L	N _{DES} =30	4.0	13.0	N/A

- (3) All Other Mixtures.

VOLUMETRIC REQUIREMENTS All Other		
Mixture Composition	Design Compactive Effort	Design Air Voids Target %
All Other	N _{DES} =30	2.0

- (4) IL-4.75 Mixture.

VOLUMETRIC REQUIREMENTS IL-4.75	
Volumetric Parameter	Requirement
Design Air Voids	4.0% at N _{design} 50
Voids in the Mineral Aggregate (VMA)	18.5% minimum
Voids Filled with Asphalt (VFA)	76-83%
Maximum Dust/AC Ratio	1.0
Maximum Draindown	0.3%

- (c) Determination of Need for Anti-Stripping Additive. The mixture designer shall determine if an additive is needed in the mix to prevent stripping. The determination will be made on the basis of tests performed according to Illinois Modified AASHTO T 283. To be considered acceptable by the Department as a mixture not susceptible to stripping, the conditioned to unconditioned split tensile strength ratio (TSR) shall be equal to or greater than 0.85 for 6 in. (150 mm) specimens. Mixtures, either with or without an additive, with TSRs less than 0.85 for 6 in. (150 mm) specimens will be considered unacceptable. Also, the conditioned tensile strength for mixtures containing an anti-strip additive shall not be lower than the original conditioned tensile strength determined for the same mixture without the anti-strip additive.

If it is determined that an additive is required, the additive may be hydrated lime, slaked quicklime, or a liquid additive, at the Contractor's option.

Dry hydrated lime shall be added at a rate of 1.0 to 1.5 percent by weight of total dry aggregate. Slurry shall be added in such quantity as to provide the required amount of hydrated lime solids by weight of total dry aggregate. The exact rate of application for all anti-stripping additives will be determined by the Engineer. The method of application shall be according to Article 1102.01(a)(11).

1030.05 Quality Control/Quality Assurance (QC/QA).

- (a) QC/QA Documents. QC/QA documents shall be as follows.

- (1) Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
- (2) Model Quality Control (QC) Addenda for Hot-Mix Asphalt (HMA) Production
- (3) Hot-Mix Asphalt QC/QA Laboratory Equipment
- (4) Illinois-Modified ASTM D 2950, Standard Test Method for Determination of Density of Bituminous Concrete In-Place by Nuclear Method
- (5) Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities
- (6) Hot-Mix Asphalt QC/QA Start-Up Procedures
- (7) Hot-Mix Asphalt QC/QA QC Personnel Responsibilities and Duties Checklist
- (8) Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples
- (9) Determination of Random Density Test Site Locations
- (10) Hot-Mix Asphalt QC/QA Control Charts/Rounding Test Values
- (11) Hot-Mix Asphalt Design Verification Procedure
- (12) Hot-Mix Asphalt Mix Design Procedure for Dust Correction Factor Determination
- (13) Development of Gradation Bands on Incoming Aggregate at Mix Plants
- (14) Bureau of Materials and Physical Research's Policy Memorandum, "Minimum Private Laboratory Requirements for Construction Materials Testing or Mix Design"
- (15) Segregation Control of Hot-Mix Asphalt
- (16) Calibration of Equipment for Asphalt Content Determination

- (b) Laboratory. The Contractor shall provide a laboratory, at the plant, according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Minimum Private Laboratory Requirements for Construction Materials Testing or Mix Design". The laboratory shall be of sufficient size and be furnished with the necessary equipment and supplies for adequately and safely performing the Contractor's QC testing. The Contractor is referred to the QC/QA document "Model Annual Quality Control Plan for Hot-Mix Asphalt (HMA) Production" for detailed information on the required laboratories. The required laboratory equipment for production and mix design is listed in the QC/QA document "Hot-Mix Asphalt QC/QA Laboratory Equipment".

The laboratory and equipment furnished by the Contractor shall be properly maintained. The Contractor shall maintain a record of calibration results at the laboratory. The Engineer may inspect measuring and testing devices at any time to confirm both calibration and condition. If the Engineer determines the equipment is not within the limits of dimensions or calibration described in the appropriate test method, the Engineer may stop production until corrective action is taken. If laboratory equipment becomes inoperable, the Contractor shall cease mix production.

- (c) Annual Quality Control (QC) Plan and Addenda. The approved Annual QC Plan and QC Addenda shall become part of the contract between the Department and the Contractor but shall not be construed, in itself, as acceptance of any HMA produced. Failure to execute the contract according to the approved Annual QC Plan and QC Addenda will result in suspension of HMA production or other appropriate actions as directed by the Engineer.

The Contractor shall submit, in writing to the Engineer, a proposed Annual QC Plan for each HMA plant for approval before each construction season. Job-specific QC Addenda to the Annual QC Plan must be submitted in writing to the Engineer for approval before the pre-construction conference. The Annual QC Plan and the QC Addenda shall address all elements involved in the production and quality control of the HMA incorporated in the project. The proposed QC Plan shall be the QC/QA document "Model Annual Quality Control Plan for Hot-Mix Asphalt (HMA) Production", and the QC Addenda shall be the QC/QA document "Model Quality Control Addendum for Hot-Mix Asphalt (HMA) Production".

Construction of HMA mixtures shall not begin without written approval of the Annual QC Plan and QC Addenda by the Engineer.

The Contractor may propose revisions to portions of the Annual QC Plan and QC Addenda. Likewise, the Annual QC Plan and QC Addenda may be amended during the progress of the work, by either party, subject to mutual agreement. Revisions require proper justification be provided to the Department by the Contractor to ensure product quality. Any revision in the Annual QC Plan or QC Addenda must be approved in writing by the Engineer.

- (d) Quality Control by Contractor. The Contractor shall perform or have performed the inspection and tests required to assure conformance to contract requirements. Control includes the recognition of obvious defects and their immediate correction. This may require increased testing, communication of test results to the plant or the job site, modification of operations, suspension of HMA production, rejection of material, or other actions as appropriate. Inability to control HMA production is cause for the Engineer to stop the operation until the Contractor completes an investigation identifying the problems causing failing test results.

The Engineer shall be immediately notified of any failing tests and subsequent remedial action. Passing tests shall be reported to the Engineer no later than the start of the next work day.

If the Contractor receives approval to use an alternative mixture to that required by the contract, the QC program will be specified by the Department.

- (1) Personnel. The Contractor shall provide a Quality Control (QC) Manager who shall have overall responsibility and authority for quality control. This individual shall have successfully completed the Department's "Hot-Mix Asphalt Level II" Technician Course.

In addition to the QC Manager, the Contractor shall provide sufficient personnel to perform the required visual inspections, sampling, testing, and documentation in a timely manner. Mix designs shall be developed by personnel who have successfully completed the Department's "Hot-Mix Asphalt Level III Course". All technicians performing mix design testing and plant sampling/testing shall have successfully completed the Department's "Hot-Mix Asphalt Level I Technician Course". The Contractor may also provide a Gradation Technician who has successfully completed the Department's "Gradation Technician Course" to run gradation tests only under the supervision of a Hot-Mix Asphalt Level II Technician. The Contractor shall provide a Hot-Mix Asphalt Density Tester who has successfully completed the Department's "Nuclear Density Testing Course" to run all required density tests on the job site.

All quality control personnel shall perform the required quality control duties. The Contractor is referred to the QC/QA document "Hot-Mix Asphalt QC/QA QC Personnel Responsibilities and Duties Checklist" for a description of personnel qualifications and duties. Testing shall be conducted to control the production of the mixture.

- (2) Plant Tests. Contractor testing of all plant samples shall be completed within 3 1/2 hours of sampling.
- a. Frequency. The Contractor shall use the test methods identified to perform the following mixture tests at a frequency not less than that indicated.

Parameter	Frequency of Tests	Frequency of Tests	Test Method See Manual of Test Procedures for Materials
	High ESAL Mixture Low ESAL Mixture	All Other Mixtures	
Aggregate Gradation % passing sieves: 1/2 in. (12.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 30 (600 μ m) No. 200 (75 μ m) Note 1.	1 washed ignition oven test on the mix per half day of production Note 4.	1 washed ignition oven test on the mix per day of production Note 4.	Illinois Procedure
Asphalt Binder Content by Ignition Oven Note 2.	1 per half day of production	1 per day	Illinois-Modified AASHTO T 308
VMA Note 3.	Day's production \geq 1200 tons: 1 per half day of production Day's production < 1200 tons: 1 per half day of production for first 2 days and 1 per day thereafter (first sample of the day)	N/A	Illinois-Modified AASHTO R 35
Air Voids Bulk Specific Gravity of Gyratory Sample	Day's production \geq 1200 tons: 1 per half day of production Day's production < 1200 tons: 1 per half day of production for first 2 days and 1 per day thereafter (first sample of the day)		
		1 per day	Illinois-Modified AASHTO T 312

Parameter	Frequency of Tests High ESAL Mixture Low ESAL Mixture	Frequency of Tests All Other Mixtures	Test Method See Manual of Test Procedures for Materials
Maximum Specific Gravity of Mixture	Day's production ≥ 1200 tons: 1 per half day of production	1 per day	Illinois-Modified AASHTO T 209
	Day's production < 1200 tons: 1 per half day of production for first 2 days and 1 per day thereafter (first sample of the day)		

Note 1. The No. 8 (2.36 mm) and No. 30 (600 μ m) sieves are not required for All Other Mixtures.

Note 2. The Engineer may waive the ignition oven requirement for asphalt binder content if the aggregates to be used are known to have ignition asphalt binder content calibration factors which exceed 1.5 percent. If the ignition oven requirement is waived, other Department approved methods shall be used to determine the asphalt binder content.

Note 3. The G_{sb} used in the voids in the mineral aggregate (VMA) calculation shall be the same average G_{sb} value listed in the mix design.

Note 4. The Engineer reserves the right to require additional hot bin gradations for batch plants if control problems are evident.

- b. Dust-to-Asphalt and Moisture Content. During production, the dust-to-asphalt binder ratio and the moisture content of the mixture at discharge from the mixer shall meet the following.

Parameter	High ESAL Mixture Low ESAL Mixture	All Other Mixtures
Ratio Dust/Asphalt Binder	0.6 to 1.2	0.6 to 1.6
Moisture	0.3 %	0.3 %

If at any time the dust-to-asphalt binder ratio or moisture content of the mixture falls outside the stated limits, production of the HMA shall cease. The cause shall be determined and corrective action satisfactory to the Engineer shall be initiated prior to resuming production.

- c. Anti-Strip Additive. During production, mixtures containing an anti-strip additive will be tested by the Department for stripping according to Illinois Modified AASHTO T 283. If the mixture fails to meet the TSR criteria for acceptance, no further mixture will be accepted until the Contractor takes such action as is necessary to furnish a mixture meeting the criteria.
- d. Small Tonnage. The Contractor may apply the following for small tonnage of mixture.

Gradation analysis, voids, and asphalt binder content tests may not be required on a specific mixture if the day's production is less than 250 tons (225 metric tons) per mix. A minimum of one set of plant tests for each mix shall be performed for each five consecutive production-day period when the accumulated tonnage produced in that period exceeds 500 tons (450 metric tons). A Hot-Mix Asphalt Level II Technician shall oversee all quality control operations. If the required tonnage of any mixture for a single pay item is less than 250 tons (225 metric tons) in total, the Contractor shall state his/her intentions of waiving the "Required Plant Tests" in the QC Addenda. The mixture shall be produced using a mix design that has been verified as specified and validated by the Department's recent acceptable field test data. A Hot-Mix Asphalt Level II Technician shall oversee all quality control operations for the mixture.

- e. Asphalt Binder Sampling. Asphalt binder samples shall be taken by the Contractor and witnessed by the Engineer at a frequency of one injection line-sample per week, per HMA plant. Sample containers will be furnished by the Department. The Engineer will submit the properly identified samples to the Bureau of Materials and Physical Research for testing.
- f. HMA Sampling. For HMA mixture sampling, the Contractor shall obtain required plant samples according to the QC/QA document, "Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples". The Contractor shall split all required samples and identify the split samples per the Engineer's instructions. These split samples shall be retained by the Contractor for assurance testing by the Engineer and be disposed of only with the permission of the Engineer. The split samples shall be stored in a dry, protected location.

The Contractor shall, when necessary, take and test additional samples (designated "check" samples) at the plant during HMA production. These samples in no way replace the required plant samples described above. Check samples shall be tested only for the parameters deemed necessary by the Contractor. Check sample test results shall be noted in the Plant Diary and shall not be plotted on the control charts. The Contractor shall detail the situations in which check samples will be taken in his/her Annual QC Plan.

- (3) Required Field Tests. The Contractor shall control the compaction process by testing the mix density at random locations as determined according to the QC/QA document, "Determination of Random Density Test Site Locations", and recording the results on forms approved by the Engineer. The Contractor shall follow the density testing procedures detailed in the QC/QA document, "Illinois-Modified ASTM D 2950, Standard Test Method for Determination of Density of Bituminous Concrete In-Place by Nuclear Method".

The Contractor shall be responsible for establishing the correlation to convert nuclear density results to core densities according to the QC/QA document, "Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities". The Engineer may require a new nuclear/core correlation if the Contractor's gauge is recalibrated during the project.

If the Contractor and Engineer agree the nuclear density test method is not appropriate for the mixture, cores shall be taken at random locations determined according to the QC/QA document "Determination of Random Density Test Site Locations". Three cores shall be taken at equal distances across the test site. These cores shall be averaged to provide a single test site result. Core densities shall be determined using the Illinois-Modified AASHTO T 166 or T 275 procedure.

Quality control density tests shall be performed at randomly selected locations within 1/2 mile (800 m) intervals and for each lift of 3 in. (75 mm) or less in thickness. For lifts in excess of 3 in. (75 mm) in thickness, a test shall be performed within 1/4 mile (400 m) intervals. Testing of lifts equal to or greater than 6 in. (150 mm) compacted thickness shall be performed in the direct transmission mode according to the QC/QA document "Illinois-Modified ASTM D 2950, Standard Test Method for Determination of Density of Bituminous Concrete In-Place by Nuclear Method". Density testing shall be accomplished intermittently throughout the day. In no case shall more than one half day's production be completed without performing density testing.

Density tests shall be performed each day on patches located nearest the randomly selected location. The daily testing frequency shall be a minimum of two density tests per mix. Density testing shall be accomplished intermittently throughout the day. In no case shall more than one half day's production be completed without performing density testing.

- (4) Control Limits. Target values shall be determined by applying adjustment factors to the AJMF where applicable. The target values shall be plotted on the control charts within the following control limits.

CONTROL LIMITS					
Parameter	High ESAL Low ESAL	High ESAL Low ESAL	All Other	IL-4.75	IL-4.75
	Individual Test	Moving Avg. of 4	Individual Test	Individual Test	Moving Avg. of 4
% Passing: ^{1/}					
1/2 in. (12.5 mm)	± 6 %	± 4 %	± 15 %		
No. 4 (4.75 mm)	± 5 %	± 4 %	± 10 %		
No. 8 (2.36 mm)	± 5 %	± 3 %			
No. 16 (1.18 mm)				± 4 %	± 3 %
No. 30 (600 μm)	± 4 %	± 2.5 %			
Total Dust Content No. 200 (75 μm)	± 1.5 %	± 1.0 %	± 2.5 %	± 1.5 %	± 1.0 %
Asphalt Binder Content	± 0.3 %	± 0.2 %	± 0.5 %	± 0.3 %	± 0.2 %
Voids	± 1.2 %	± 1.0 %	± 1.2 %	± 1.2 %	± 1.0 %
VMA	-0.7 % ^{2/}	-0.5 % ^{2/}			

1/ Based on washed ignition oven

2/ Allowable limit below minimum design VMA requirement

DENSITY CONTROL LIMITS		
Mixture Composition	Parameter	Individual Test
IL-4.75	N _{design} = 50	93.0 - 97.4 % ^{1/}
IL-9.5, IL-12.5	N _{design} ≥ 90	92.0 - 96.0 %
IL-9.5, IL-9.5L, IL-12.5	N _{design} < 90	92.5 - 97.4 %
IL-19.0, IL-25.0	N _{design} ≥ 90	93.0 - 96.0 %
IL-19.0, IL-19.0L, IL-25.0	N _{design} < 90	93.0 - 97.4 %
All Other	N _{design} = 30	93.0 ^{2/} - 97.4 %

1/ Density shall be determined by cores or by correlated, approved thin lift nuclear gauge.

2/ 92.0 % when placed as first lift on an unimproved subgrade.

- (5) Control Charts. Standardized control charts shall be maintained by the Contractor at the field laboratory. The control charts shall be displayed and be accessible at the field laboratory at all times for review by the Engineer.

Individual required test results obtained by the Contractor shall be recorded on the control chart immediately upon completion of a test, but no later than 24 hours after sampling. Only the required tests and resamples shall be recorded on the control chart. Any additional testing of check samples may be used for controlling the Contractor's processes, but shall be documented in the plant diary.

The results of assurance tests performed by the Engineer will be posted as soon as available.

The following parameters shall be recorded on standardized control charts as described in the QC/QA document "Hot-Mix Asphalt QC/QA Control Charts/Rounding Test Values".

Control limits for each required parameter, both individual tests and the average of four tests, shall be exhibited on control charts. Test results shall be posted within the time limits previously outlined.

CONTROL CHART REQUIREMENTS	High ESAL Low ESAL	All Other
Gradation ^{1/}	% Passing Sieves: 1/2 in. (12.5 mm) No. 4 (4.75 mm) No. 8 (2.36 mm) No. 30 (600 µm)	% Passing Sieves: 1/2 in. (12.5 mm) No. 4 (4.75 mm)
Total Dust Content ^{1/}	No. 200 (75 µm)	No. 200 (75 µm)
	Asphalt Binder Content	Asphalt Binder Content
	Bulk Specific Gravity	Bulk Specific Gravity
	Maximum Specific Gravity of Mixture	Maximum Specific Gravity of Mixture
	Voids	Voids
	Density	Density
	VMA	

1/ Based on washed ignition oven

(6) Corrective Action for Required Plant Tests.

- a. Individual Test Results. When an individual test result exceeds its control limit, the Contractor shall immediately resample and retest. If at the end of the day no material remains from which to resample, the first sample taken the following day shall serve as the resample as well as the first sample of the day. This result shall be recorded as a retest. If the retest passes, the Contractor may continue the required plant test frequency. Additional check samples should be taken to verify mix compliance.

1. Voids, VMA, and Asphalt Binder Content.

- (a.) High ESAL and Low ESAL Mixtures. If the retest for voids, VMA, or asphalt binder content exceeds control limits, HMA production shall cease and immediate corrective action shall be instituted by the Contractor. After corrective action, HMA production shall be restarted, the HMA production shall be stabilized, and the Contractor shall immediately resample and retest. HMA production

may continue when approved by the Engineer. The corrective action shall be documented.

- (b.) All Other- Mixtures. If the retest for voids or asphalt binder content exceeds control limits, immediate corrective action shall be instituted by the Contractor. After corrective action, the Contractor shall immediately resample and retest. The corrective action shall be documented.

If corrective action has been initiated and the second resample fails, the Contractor shall cease operations. Failure to cease production shall subject all subsequently produced materials to be considered unacceptable.

- 2. Gradation. For gradation retest failures, immediate corrective action shall be instituted by the Contractor. After corrective action, the Contractor shall immediately resample and retest. The corrective action shall be documented.

- b. Moving Average. When the moving average values trend toward the moving average control limits, the Contractor shall take corrective action and increase the sampling and testing frequency. The corrective action shall be documented.

The Contractor shall notify the Engineer whenever the moving average values exceed the moving average control limits. If two consecutive moving average values fall outside the moving average control limits, the Contractor shall cease operations. Corrective action shall be immediately instituted by the Contractor. Operations shall not be reinstated without the approval of the Engineer. Failure to cease operations shall subject all subsequently produced material to be considered unacceptable.

- c. Dust Control. If the washed ignition oven gradation test results indicate a problem with controlling dust, corrective action to control the dust shall be taken and approved by the Engineer. If the Engineer determines that Positive Dust Control Equipment is necessary, the equipment as specified in Article 1102.01(d)(7), shall be installed prior to the next construction season.
- d. HMA Production Control. If the Contractor is not controlling the production process and is making no effort to take corrective action, the operation shall stop.

- (7) Corrective Action for Required Field Tests (Density). When an individual density test exceeds the control limits, the Contractor shall immediately retest in a location that is halfway between the failed test site and the finish roller. If the retest passes, the Contractor shall continue the normal density test frequency. An additional density check test should be performed to verify the mix compaction.

If the retest fails, the Contractor shall immediately conduct one of the following procedures.

- a. Low Density. If the failing density retest indicates low densities, the Contractor shall immediately increase the compaction effort, review all mixture test results representing the HMA being produced, and make corrective action as needed. The Contractor shall immediately perform a second density retest within the area representing the increased compaction effort and mixture adjustments.
- b. High Density. If the failing density retest indicates high densities, the Contractor shall cease production and placement until all mixture test results are reviewed and corrective action is taken. If the high density failure is a result of a change in the mixture, any existing material in the surge bin may be subject to rejection by the Engineer. After restart of HMA production, a second density retest shall then be performed in the area representing the mixture adjustments.

If the second retest from either procedure passes, production and placement of the HMA may continue. The increased compaction effort for low density failures shall not be reduced to that originally being used unless it is determined by investigation that the cause of the low density was unrelated to compaction effort, the cause was corrected, and tests show the corrective action has increased the density within the required limits.

If the second retest fails, production and placement of the HMA shall cease until the Contractor has completed an investigation and the problem(s) causing the failing densities has/have been determined. If the Contractor's corrective action is approved by the Engineer, production and placement of the HMA may then be resumed. The Contractor shall increase the frequency of density testing to show, to the satisfaction of the Engineer, that the corrective action taken has corrected the density problem.

If the Contractor is not controlling the compaction process and is making no effort to take corrective action, the operation, as directed by the Engineer, shall stop.

- (e) Quality Assurance by the Engineer. The Engineer will conduct independent assurance tests on split samples taken by the Contractor for quality control testing. In addition, the Engineer will witness the sampling and splitting of these samples a minimum of twice a month and will immediately retain the samples for quality assurance testing.

The overall testing frequency will be performed over the entire range of Contractor samples and will be equal to or greater than ten percent for gradations and equal to or greater than 20 percent for asphalt binder content, bulk specific gravity, maximum specific gravity and field density. The Engineer may select any or all split samples for assurance testing. The

Engineer will initiate independent assurance testing during mixture field verification. These tests may be performed immediately or anytime up to ten working days after sampling. The test results will be made available to the Contractor as soon as they become available.

The Contractor's nuclear/core correlation will be verified utilizing Department nuclear gauges.

The Engineer may witness the sampling and testing being performed by the Contractor. The Engineer will document all witnessed samples and tests.

The Engineer will promptly notify the Contractor, both verbally and in writing, of observed deficiencies. If the Engineer observes that the sampling and quality control tests are not being performed according to the applicable test procedures, the Engineer may stop production until corrective action is taken.

The Engineer may elect to obtain samples for testing, separate from the Contractor's quality control process, to verify specification compliance. No more than 20 cores per day will be required by the Engineer for the purpose of acceptance and/or comparison with nuclear gauge measurements. The cost of this work will not be paid for separately, but shall be considered as included in the unit price bid for the HMA item involved. Differences between the Contractor's and the Engineer's split sample test results will be considered acceptable if within the following limits.

Test Parameter	Acceptable Limits of Precision
% Passing: ^{1/}	
1/2 in. (12.5 mm)	5.0 %
No. 4 (4.75 mm)	5.0 %
No. 8 (2.36 mm)	3.0 %
No. 30 (600 µm)	2.0 %
Total Dust Content No. 200 (75 µm)	2.2 %
Asphalt Binder Content	0.3 %
Maximum Specific Gravity of Mixture	0.026
Bulk Specific Gravity	0.030
VMA	1.4 %
Density (% Compaction)	1.0 % (Correlated)

1/ Based on washed ignition.

The Department may run extractions for assurance, when deemed necessary by the Engineer.

In the event comparison of the required plant test results is outside the above acceptable limits of precision, Department split or independent samples fail the control limits, a Department extraction indicates non-

compliance, or a continual trend of difference between Contractor and Department test results is identified, the Engineer will immediately investigate. The Engineer may suspend production as stated in Article 108.07 of the Standard Specifications, while the investigation is in progress. The investigation may include testing by the Engineer of any remaining split samples or a comparison of split sample test results on the HMA currently being produced. The investigation may also include review and observation of the Contractor's technician performance, testing procedure, and equipment.

If a problem is identified with the mix, the Contractor shall take immediate corrective action. After corrective action, both the Contractor and the Engineer shall immediately resample and retest according to Article 1030.05(d)(6).

In the event comparison of the required field test results (densities) are outside the above acceptable limits of precision, Department split or independent samples fail the density limits, or a continual trend of difference between Contractor and Department test results is identified, the Engineer will immediately investigate. The investigation will include testing by the Engineer of any remaining random density locations. The Engineer may establish additional locations for testing by both the Contractor and the Department to provide further comparison results. The investigation shall also include review and observation of the Density Tester performance, testing procedure, and equipment. The original correlation and/or comparison data, for both gauges, shall be reviewed as part of the investigation process. If the problem continues, the Engineer may require a new correlation be performed.

- (f) Acceptance by the Engineer. Final acceptance will be based on the following.
 - (1) Validation of the Contractor's quality control by the assurance process.
 - (2) The Contractor's process control charts and actions.
 - (3) Department assurance tests for voids, field VMA, and density.

If any of the above is not met, the work will be considered in non-conformance with the contract.

- (g) Documentation. The Contractor shall be responsible for documenting all observations, records of inspection, adjustments to the mixture, test results, retest results, and corrective actions in a bound hardback field book or bound hardback diary which will become the property of the Department.

The Contractor shall be responsible for the maintenance of all permanent records whether obtained by the Contractor, the Contractor's consultants, or the producer of the HMA.

The Contractor shall provide the Engineer full access to all documentation throughout the progress of the work.

Adjustments to mixture production and test results shall be recorded in duplicate and sent to the Engineer on forms approved by the Engineer.

Each construction season, prior to production of HMA, the Contractor shall submit to the Engineer, on appropriate forms, documentation that the HMA plant(s) have been calibrated and approved.

1030.06 Start of HMA Production and Job Mix Formula (JMF) Adjustments. The start of HMA production and JMF adjustments shall be as follows.

- (a) High ESAL Mixture and Low ESAL Mixture. During the mixture start-up the Contractor shall follow the QC/QA document "Hot-Mix Asphalt QC/QA Start-Up Procedures".

At the start of HMA production, QC/QA mixture start-up will be required for the following situations: at the beginning of production of a new mixture design, at the beginning of each production season, and at every plant utilized to produce mixtures, regardless of the mix.

Before start-up, target values shall be determined by applying gradation correction factors to the JMF when applicable. These correction factors shall be determined from previous experience. The target values, when approved by the Engineer, shall be used to control HMA production. Plant settings and control charts shall be set according to target values.

In the field, slight adjustments to the JMF or minor changes in cold-feed/hot-bin blends may be necessary to obtain the desired air voids, density, uniformity, and constructibility. After any JMF adjustment, the JMF shall become the Adjusted Job Mix Formula (AJMF). Upon completion of the first acceptable test strip, the JMF shall become the AJMF regardless of whether or not the JMF has been adjusted. If an adjustment/plant change is made, the Engineer may require a new test strip to be constructed. If the HMA placed during the initial test strip is determined to be unacceptable to remain in place by the Engineer, it shall be removed and replaced.

The limitations between the JMF and AJMF are as follows.

Parameter	Adjustment
1/2 in. (12.5 mm)	± 5.0 %
No. 4 (4.75 mm)	± 4.0 %
No. 8 (2.36 mm)	± 3.0 %
No. 30 (600 µm)	*
No. 200 (75 µm)	*
Asphalt Binder Content	± 0.3 %

- * In no case shall the target for the amount passing be greater than the JMF.

Any adjustments outside the above limitations will require a new mix design.

After an acceptable test strip, including required plant tests, production of HMA shall be restarted the same day, and an acceptable rolling pattern shall be established in the first 200 tons (180 metric tons) of HMA produced. Paving may continue for the remainder of the day. After an acceptable rolling pattern has been established, it shall not be changed unless approved by the Engineer.

If a mixture start-up is not required, an acceptable rolling pattern shall be developed during the first 300 tons (275 metric tons) of each mixture produced.

A nuclear/core correlation, if required by the Engineer, shall follow the QC/QA document "Standard Test Method for Correlating Nuclear Gauge Densities with Core Densities" and shall be performed by the Contractor during the first production day.

Regardless which QC procedures are used during start of HMA production, the next day's production shall not resume until all test results, including an acceptable nuclear/core correlation, are available and an AJMF is agreed upon by the Contractor and Engineer.

- (b) All Other Mixtures. In the field, slight adjustments to the gradation and/or asphalt binder content may be necessary to obtain the desired air voids, density, uniformity, and constructibility. These adjustments define the Adjusted Job Mix Formula (AJMF) and become the target values for quality control operations. Limitations between the JMF and AJMF are as follows. Any adjustments outside the limitations will require a new mix design.

Parameter	Adjustment
1/2 in. (2.5 mm)	± 6 %
No. 4 (4.75 mm)	± 5 %
No. 200 (75 µm)	± 2.5 %
Asphalt Binder Content	± 0.5 %

Production is not required to stop after a growth curve has been constructed. The test results shall be available to both the Contractor and Engineer before production may resume the following day.

During production, the Contractor and Engineer shall continue to evaluate test results and mixture laydown and compaction performance. Adjustments within the above requirements may be necessary to obtain the desired mixture properties. If an adjustment/plant change is made, the Engineer may request additional growth curves and supporting plant tests.

1030.07 Preparation of Mixture for Cracks, Joints, and Flangeways. When the mixture is prepared in a batch-type mixing plant, the heated aggregate and the asphalt binder shall be measured separately and accurately by weight or by volume. The heated aggregate and asphalt binder shall be mixed in a pug mill mixer. When the aggregate is in the mixer, the asphalt binder shall be added and mixing continued

until a homogeneous mixture is produced in which all particles of aggregate are coated uniformly. The mixing time will be determined by the Engineer.

When the mixture is prepared in a continuous-type mixing plant, the heated aggregate and asphalt binder shall be measured separately and accurately by volume. The heated aggregate and asphalt binder shall be mixed in the pug mill mixer for a period of time necessary to produce a homogeneous mixture in which all particles of aggregate are coated uniformly. The mixing time will be determined by the Engineer.

When the mixture is prepared in a dryer drum plant, the heated aggregate and asphalt binder shall be accurately proportioned and mixed in the dryer drum plant.

For all types of plants, the ingredients shall be combined in such proportions as to produce a mixture according to the following composition limits by weight.

Mixture Composition	
Fine Aggregate (FA 1, FA 2 or FA 3)	93-96 %
Asphalt Binder (PG58-22, PG64-22)	6-9 %

With the permission of the Engineer, an approved cold-lay sand asphalt mixture may be used in lieu of the above mixture.

1030.08 Transportation. Vehicles used in transporting HMA shall have clean and tight beds. The beds shall be sprayed with asphalt release agents from the Department's approved list. In lieu of a release agent, the Contractor may use a light spray of water with a light scatter of manufactured sand (FA 20 or FA 21) evenly distributed over the bed of the vehicle. After spraying, the bed of the vehicle shall be in a completely raised position and it shall remain in this position until all excess asphalt release agent or water has been drained.

When the air temperature is below 60 °F (15 °C), the bed, including the end, endgate, sides and bottom shall be insulated with fiberboard, plywood, or other approved insulating material and shall have a thickness of not less than 3/4 in. (20 mm). When the insulation is placed inside the bed, the insulation shall be covered with sheet steel approved by the Engineer. Each vehicle shall be equipped with a cover of canvas or other suitable material meeting the approval of the Engineer which shall be used if any one of the following conditions is present.

- (a) Ambient air temperature is below 60 °F (15 °C).
- (b) The weather is inclement.
- (c) The temperature of the HMA immediately behind the paver screed is below 250 °F (120 °C).

The cover shall extend down over the sides and ends of the bed for a distance of approximately 12 in. (300 mm) and shall be fastened securely. The covering shall be rolled back before the load is dumped into the finishing machine.

SECTION 1031. RECLAIMED ASPHALT PAVEMENT

1031.01 Description. RAP is reclaimed asphalt pavement resulting from cold milling or crushing of an existing dense graded hot-mix asphalt (HMA) pavement. The Contractor shall supply written documentation that the RAP originated from routes or airfields under federal, state or local agency jurisdiction.

1031.02 Stockpiles. The Contractor shall construct individual, sealed RAP stockpiles meeting one of the following definitions. No additional RAP shall be added to the pile after the pile has been sealed.

- (a) **Homogeneous.** Homogeneous RAP stockpiles shall consist of RAP from Class I, Superpave (High ESAL), HMA (High ESAL), or equivalent, mixtures only and represent; 1) the same aggregate quality, but shall be at least C quality or better; 2) the same type of crushed aggregate (either crushed natural aggregate, ACBF slag, or steel slag); 3) similar gradation; and 4) similar asphalt binder content. If approved by the Engineer, combined single pass surface/binder millings may be considered "homogenous", with a quality rating dictated by the lowest coarse aggregate quality present in the mixture. Stockpiles shall meet the testing requirements of Article 1031.07. Stockpiles not meeting these requirements may be processed (crushing and screening) and retested.
- (b) **Conglomerate.** Conglomerate RAP stockpiles shall consist of RAP from Class I, Superpave (High ESAL), HMA (High ESAL), or equivalent, mixtures only. The coarse aggregate in this RAP shall be crushed aggregate only and may represent more than one aggregate type and/or quality but shall be at least C quality or better. This RAP may have an inconsistent gradation and/or asphalt binder content prior to processing. All conglomerate RAP shall be processed prior to testing by crushing to where all RAP shall pass the 5/8 in. (16 mm) or smaller screen. Stockpiles shall not contain steel slag or other expansive material as determined by the Department. Stockpiles shall meet the testing requirements of Article 1031.07.
- (c) **Conglomerate "D" Quality (DQ).** Conglomerate DQ RAP stockpiles shall consist of RAP containing coarse aggregate (crushed or round) that is at least D quality or better. Conglomerate DQ RAP stockpiles shall not contain steel slag or other expansive material as determined by the Department. Conglomerate DQ RAP shall meet the testing requirements of Article 1031.07.

Reclaimed Superpave (Low ESAL)/HMA (Low ESAL) IL-19.0L binder and IL-9.5L surface mixtures shall be placed in conglomerate DQ RAP stockpiles due to potential of rounded aggregate.

- (d) **Other.** RAP stockpiles that do not meet the requirements of the stockpile categories listed above shall be classified as "Other". "Other" RAP stockpiles shall not be used in HMA.

1031.03 Contaminants. RAP containing contaminants, such as earth, brick, sand, concrete, sheet asphalt, bituminous surface treatment (i.e. chip seal), pavement fabric, joint sealants, etc., will be unacceptable unless the contaminants

are removed to the satisfaction of the Engineer. Sheet asphalt shall be stockpiled separately.

1031.04 Quality Designation of Aggregate in RAP. The use of RAP in HMA shall be set by the lowest quality of coarse aggregate in the RAP stockpile and are designated as follows.

- (a) RAP from Class I, Superpave (High ESAL) or HMA (High ESAL) surface mixtures are designated as containing Class B quality coarse aggregate only.
- (b) RAP from Superpave (Low ESAL)/HMA (Low ESAL) IL-19.0L binder and IL-9.5L surface mixtures are designated as Class C quality coarse aggregate only.
- (c) RAP from Class I, Superpave (High ESAL), or HMA (High ESAL) binder mixtures, bituminous base course mixtures, and bituminous base course widening mixtures are designated as containing Class C quality coarse aggregate only.
- (d) RAP from bituminous stabilized subbase and BAM shoulders are designated as containing Class D quality coarse aggregate only.

The Contractor shall supply written documentation that the RAP meets the above quality designations.

Any mixture not listed above shall have the designated quality determined by the Department.

1031.05 RAP in HMA. The use of RAP in HMA shall be as follows.

- (a) Coarse Aggregate Size. The coarse aggregate in all RAP shall be equal to or less than the nominal maximum size requirement for the HMA mixture to be produced using RAP.
- (b) Steel Slag Stockpiles. RAP stockpiles containing steel slag or other expansive material, as determined by the Department, shall be homogeneous and will be approved for use in HMA (High ESAL and Low ESAL) surface mixtures only.
- (c) Use in High and Low ESAL Mixtures. RAP stockpiles for use in HMA mixtures (High ESAL and Low ESAL) shall be either homogeneous or conglomerate, except conglomerate stockpiles shall not be used in HMA surface mixture Ndesign 50 or greater.
- (d) Use in Shoulders and Subbase. RAP stockpiles for use in HMA shoulders and stabilized subbase (HMA) shall be homogeneous, conglomerate, or conglomerate DQ.

1031.06 RAP in Aggregate Surface Course and Aggregate Shoulders. The use of RAP in Aggregate Surface Course and Aggregate Shoulders shall be as follows.

- (a) Stockpiles. RAP stockpiles may be any of those listed in Article 1031.02.
- (b) Gradation. One hundred percent of the RAP material shall pass the 1 1/2 in. (37.5 mm) sieve. The RAP material shall be reasonably well graded from coarse to fine. RAP material that is gap-graded or single sized will not be accepted.
- (c) Exclusion. The requirements of Article 1031.07 do not apply.

1031.07 Testing. All RAP shall be sampled and tested either during or after stockpiling.

For testing during stockpiling, washed extraction samples shall be run at the minimum frequency of one sample per 500 tons (450 metric tons) for the first 2000 tons (1800 metric tons) and one sample per 2000 tons (1800 metric tons) thereafter. A minimum of five tests shall be required for stockpiles less than 4000 tons (3600 metric tons).

For testing existing stockpiles, the Contractor shall submit a plan for approval to the District proposing a satisfactory method of sampling and testing the RAP pile either in-situ or by restockpiling. The sampling plan shall meet the minimum frequency required above and detail the procedure used to obtain representative samples throughout the pile for testing.

Each field sample shall be split to obtain two samples for testing. One of the test samples from the final split shall be labeled and stored for Department use. The Contractor shall extract the other test sample according to Illinois Modified AASHTO T 164. The Engineer reserves the right to test any sample (split or Department-taken) to verify Contractor test results.

All of the extraction results shall be compiled and averaged for asphalt binder content and gradation. Individual extraction test results, when compared to the averages, will be accepted if within the tolerances listed below.

Parameter	Homogeneous / Conglomerate	Conglomerate "D" Quality
1 in. (25 mm)		± 5 %
1/2 in. (12.5 mm)	± 8 %	± 15 %
No. 4 (4.75 mm)	± 6 %	± 13 %
No. 8 (2.36 mm)	± 5 %	
No. 16 (1.18 mm)		± 15 %
No. 30 (600 µm)	± 5 %	
No. 200 (75 µm)	± 2.0 %	± 4.0 %
Asphalt Binder	± 0.4 %	± 0.5 %

If more than 20 percent of the individual sieves are out of the gradation tolerances, or if more than 20 percent of the asphalt binder content test results fall outside the appropriate tolerances, the RAP shall not be used in HMA unless the

RAP representing the failing tests is removed from the stockpile. All test data and acceptance ranges shall be sent to the District for evaluation.

If additional RAP stockpiles are tested and found that no more than 20 percent of the results are outside of the control tolerances set for the original RAP stockpile and HMA mix design, the additional RAP stockpiles may be used in the original mix design at the percent previously verified.

With the approval of the Engineer, the ignition oven may be substituted for extractions according to the Illinois Test Procedure, "Calibration of the Ignition Oven for the Purpose of Characterizing Reclaimed Asphalt Pavement (RAP)".

SECTION 1032. BITUMINOUS MATERIALS

1032.01 Description. Bituminous materials shall include asphalt binders, emulsified asphalts, rapid curing liquid asphalt, medium curing liquid asphalts, slow curing liquid asphalts, asphalt fillers, and road oils. All bituminous materials used in a given construction shall be uniform in character, appearance, and consistency.

1032.02 Measurement of Volume. Measurement of the volume of asphalt binders, emulsified asphalts, rapid curing liquid asphalt, medium curing liquid asphalts, slow curing liquid asphalts, asphalt fillers, and road oils will be based on the volume of the material at 60 °F (15.6 °C). Volumes measured at higher or lower temperatures will be corrected to the volume at 60 °F (15.6 °C) using the Standard ASTM-IP Petroleum Measurement Tables, ASTM D 1250.

Payment will not be made for bituminous materials in excess of 105 percent of the amount specified by the Engineer.

When bituminous materials are delivered by tank truck from a refinery or from a storage tank, a weight ticket for each truck load shall be furnished to the inspector. The ticket shall show the weight of the empty truck (the truck being weighed each time before it is loaded), the weight of the loaded truck, and the net weight of the bituminous material. If the material is being measured for payment by the gallon (liter), the specific gravity at 60 °F/60 °F (15.6 °C/15.6 °C) of the bituminous material in the tank truck and the number of gallons (liters) at 60 °F (15.6 °C) shall be shown on the weight ticket.

1032.03 Delivery. When bituminous materials are not approved at their source by the Department, they shall be delivered far enough in advance of their use to permit the necessary tests to be made. When not delivered in tank cars or tank trucks, the bituminous materials shall be delivered in suitable containers or packages, plainly labeled to show the kind of material, the name of manufacturer, and the lot or batch number. Each shipment and each carload shall be kept separate until the material has been accepted.

Asphalt binder, when delivered in tank cars or tank trucks, shall be delivered at a temperature not to exceed 350 °F (175 °C).

Petroleum asphalts PAF-1 and PAF-2 shall be shipped in new, double end, metal drums. The thickness of the metal used shall not be less than 0.0149 in. (0.4 mm). The side seams of the drums shall be double lapped, spot welded single lapped, or stitch welded single lapped. The seams shall meet the approval of the Engineer. The drums shall be manufactured so that there will be no leakage during hot weather. The capacity of each drum shall be approximately 460 lb (210 kg), the drums being 35 in. (890 mm) maximum in height and approximately 22 in. (560 mm) in diameter.

Petroleum asphalts PAF-3 and PAF-4 shall be shipped in new, open end, metal drums. The thickness of the metal used shall be not less than the 0.0149 in. (0.4 mm). The seams shall be constructed so that the filled drums will withstand shipping and handling. The inside of the drums shall be coated with talc or other approved material to facilitate peeling. The capacity of each drum shall be approximately 460 lb (210 kg), the drums being 35 in. (890 mm) maximum in height and approximately 22 in. (560 mm) in diameter. Petroleum asphalts PAF-3 and PAF-4 may, when specified, be shipped in approved 100 lb (45 kg) cartons.

1032.04 Spraying Application. The spraying application temperature ranges for bituminous material applied by a pressure distributor shall be according to the following table.

Spraying Application Temperature Ranges		
Type and Grade of Bituminous Material	Temperature Ranges	
	°F min. - max.	°C min. - max.
PEP	60 - 130	15 - 55
MC-30	85 - 190	30 - 90
MC-70, RC-70, SC-70	120 - 225	50 - 105
MC-250, SC-250	165 - 270	75 - 130
MC-800, SC-800	200 - 305	95 - 150
MC-3000, SC-3000	230 - 345	110 - 175
PG 46-28	275 - 385	135 - 195
PG 52-28	285 - 395	140 - 200
RS-2, CRS-2	110 - 160	45 - 70
SS-1, SS-1h, CSS-1, CSS-1h	75 - 130	25 - 55
SS-1hP, CSS-1hP	75 - 130	25 - 55
HFE-90, HFE-150, HFE-300	150 - 180	65 - 80
HFP, CRSP, HFRS-2	150 - 180	65 - 80
E-2	85 - 190	30 - 90
E-3	120 - 225	50 - 105
E-4	165 - 270	75 - 130

1032.05 Asphalt Binder (Prepared from Petroleum). These materials will be accepted according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Performance Graded Asphalt Binder Acceptance Procedure". These materials shall be free from water and shall not foam when heated to any temperature below the actual flash point.

When requested, producers shall provide the Engineer with viscosity/temperature relationships for the performance graded asphalt binders delivered and incorporated in the work.

- (a) Performance Graded (PG) Asphalt Binder. The asphalt binder shall meet the requirements of AASHTO M 320, Table 1 "Standard Specification for Performance Graded Asphalt Binder" for the grade shown on the plans. Air blown asphalt will not be allowed.
- (b) Modified Performance Graded (PG) Asphalt Binder. The asphalt binder shall meet the requirements of AASHTO M 320, Table 1 "Standard Specification for Performance Graded Asphalt Binder" for the grade shown on the plans. Elastomers shall be added to the base asphalt binder to achieve the specified performance grade and shall be either a styrene-butadiene diblock or triblock copolymer without oil extension, or a styrene-butadiene rubber. Air blown asphalts, acid modification, and other modifiers will not be allowed. Asphalt modification at hot-mix asphalt plants will not be allowed. The modified asphalt binder shall be smooth, homogeneous, and be according to the requirements shown in Table 1 or 2 for the grade shown on the plans.

Table 1 - Requirements for Styrene-Butadiene Copolymer (SB/SBS) Modified Asphalt Binders		
Test	Asphalt Grade SB/SBS PG 64-28 SB/SBS PG 70-22 SB/SBS PG 70-28	Asphalt Grade SB/SBS PG 76-22 SB/SBS PG 76-28
Separation of Polymer Illinois Test Procedure, "Separation of Polymer from Asphalt Binder" Difference in °F (°C) of the softening point between top and bottom portions.	4 (2) max.	4 (2) max.
Force Ratio AASHTO T 300, (f_2/f_1), 39.2 °F (4 °C), 50 mm/min., 300 mm elongation.	0.30 min.	0.35 min.
TESTS ON RESIDUE FROM ROLLING THIN FILM OVEN TEST (AASHTO T 240)		
Elastic Recovery ASTM D 6084, Procedure A, 77 °F (25 °C), 100 mm elongation, %	60 min.	70 min.

Note. When SBS/SBR PG 76-22 or SBS/SBR PG 76-28 is specified for mixture IL-4.75, the elastic recovery shall be a minimum of 80.

Table 2 - Requirements for Styrene-Butadiene Rubber (SBR) Modified Asphalt Binders		
Test	Asphalt Grade SBR PG 64-28 SBR PG 70-22 SBR PG 70-28	Asphalt Grade SBR PG 76-22 SBR PG 76-28
Separation of Polymer Illinois Test Procedure, "Separation of Polymer from Asphalt Binder" Difference in °F (°C) of the softening point between top and bottom portions.	4 (2) max.	4 (2) max.
Toughness ASTM D 5801, 77 °F (25 °C), 20 in./min. (500 mm/min.), in.-lbs (N-m).	110 (12.5) min.	110 (12.5) min.
Tenacity ASTM D 5801, 77 °F (25 °C), 20 in./min. (500 mm/min.), in.-lbs (N-m).	75 (8.5) min.	75 (8.5) min.
TESTS ON RESIDUE FROM ROLLING THIN FILM OVEN TEST (AASHTO T 240)		
Elastic Recovery ASTM D 6084, Procedure A, 77 °F (25 °C), 100 mm elongation, %	40 min.	50 min.

Note. When SBS/SBR PG 76-22 or SBS/SBR PG 76-28 is specified for mixture IL-4.75, the elastic recovery shall be a minimum of 80.

1032.06 Emulsified Asphalts. Emulsified asphalts will be accepted according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Emulsified Asphalt Acceptance Procedure". These materials shall be homogeneous and shall show no separation of asphalt after thorough mixing, within 30 days after delivery, provided separation has not been caused by freezing. They shall coat the aggregate being used in the work to the satisfaction of the Engineer and shall be according to the following requirements.

- (a) Anionic Emulsified Asphalt. Anionic emulsified asphalts shall be according to AASHTO M 140.
- (b) Cationic Emulsified Asphalt. Cationic emulsified asphalts shall be according to AASHTO M 208.

- (c) High Float Emulsion. High float emulsions are medium setting and shall be according to the following table.

Test	HFE-90	HFE-150	HFE-300
Viscosity, Saybolt Furol, at 122 °F (50 °C), (AASHTO T 59), SFS ^{1/}	50 min.	50 min.	50 min.
Sieve Test, No. 20 (850 µm), retained on sieve, (AASHTO T 59), %	0.10 max.	0.10 max.	0.10 max.
Settlement, (AASHTO T 59), % ^{2/}	5 max.	5 max.	5 max.
Storage Stability Test, 1 day, (AASHTO T 59), % ^{3/}	1 max.	1 max.	1 max.
Coating Test (All Grades), (AASHTO T 59), 3 minutes	stone coated thoroughly		
Distillation Test, (AASHTO T 59): Residue from distillation test to 500 °F (260 °C), % Oil distillate by volume, %	65 min. 7 max.	65 min. 7 max.	65 min. 7 max.
Characteristics of residue from distillation test to 500 °F (260 °C): Penetration at 77 °F (25 °C), (AASHTO T 49), 100 g, 5 sec, dmm	90-150	150-300	300 min.
Float Test at 140 °F (60 °C), (AASHTO T 50), sec.	1200 min.	1200 min.	1200 min.

1/ The emulsion shall be pumpable.

2/ The test requirement for settlement may be waived when the emulsified asphalt is used in less than five days time; or the purchaser may require that the settlement test be run from the time the sample is received until it is used, if the elapsed time is less than five days.

3/ The 24 hour (one-day) storage stability test may be used instead of the five-day settlement test.

- (d) Penetrating Emulsified Prime (PEP). The PEP shall be according to the following requirements when tested according to AASHTO T 59.

Test	Result
Viscosity, Saybolt Furol, at 77 °F (25 °C), SFS	75 max.
Sieve test, retained on No. 20 (850 µm) sieve, %	0.10 max.
Distillation to 500 °F (260 °C) residue, %	38 min.
Oil distillate by volume, %	4 max.

The PEP shall be tested according to the current Bureau of Materials and Physical Research Illinois Test Procedure, "Sand Penetration Test of Penetrating Emulsified Prime (PEP)". The time of penetration shall be equal to or less than that of MC-30. The depth of penetration shall be equal to or greater than that of MC-30.

- (e) CSS-1h Latex Modified Emulsified Asphalt. The emulsified asphalt shall be a quick traffic latex modified asphalt emulsion containing a minimum of 3.0 percent latex solids by weight of asphalt binder. The latex shall be milled or blended into the emulsifier solution prior to the emulsification process. The CSS-1h latex modified emulsified asphalt shall be according to the following.

Test (AASHTO T 59)	Result
Viscosity, Saybolt Furol, 77 °F (25 °C), SFS	20-100
Storage Stability Test, 24 hours, %	1 max.
Particle Charge Test	Positive
Sieve Test, No. 20 (850 µm), retained on sieve, %	0.10 max.
Distillation Test, Residue from distillation test to 347 ± 9 °F (175 ± 5 °C), %	62 min.

Tests on residue from distillation	Result
Penetration, 77 °F (25 °C), 100 grams, 5 seconds, (AASHTO T 49), dmm	40-90
Ductility, 77 °F (25 °C), 50 mm/min, (AASHTO T 51), mm	400 min.
Solubility in trichloroethylene, (AASHTO T 44), %	97.5 min.
Softening Point, (AASHTO T 53), °F (°C)	135 (57) min.
Absolute Viscosity, 140 °F (60 °C), (AASHTO T 202), Poises (Pa·sec)	8000 (800) min.

- (f) Polymer Modified Emulsified Asphalt. Polymer modified emulsified asphalts SS-1hP, CSS-1hP, CRSP, and HFP shall be according to the following.
- (1) Polymer modified emulsified asphalts SS-1hP (anionic) or CSS-1hP (cationic) shall be according to the SS-1h requirements of Article 1032.06(a) or the CSS-1h requirements of Article 1032.06(b), respectively, with the following exceptions for both types.
- The emulsified asphalt shall be modified with a styrene-butadiene diblock or triblock copolymer, or a styrene-butadiene rubber.
 - The cement mixing and ductility tests will be waived.
 - Upon examination of the storage stability test cylinder after standing undisturbed for 24 hours, the surface shall show no white, milky colored substance and shall be a homogenous brown color throughout.
 - The distillation for polymer modified emulsion shall be performed according to AASHTO T 59, except the temperature shall be 374 ± 9 °F (190 ± 5 °C) and measured using an ASTM 16F (16C) thermometer.

- e. The residue from distillation shall have a minimum elastic recovery value of 30 percent when tested according to AASHTO T 301. The specified temperature shall be 39.2 ± 1.0 °F (4.0 ± 0.5 °C).
- (2) Polymer modified emulsified asphalts CRSP (Cationic Rapid Setting) and HFP (Anionic High Float) shall be according to the following.
- a. The emulsified asphalt shall be modified with a styrene-butadiene diblock or triblock copolymer, or a styrene-butadiene rubber.
- b. Upon examination of the storage stability test cylinder after standing undisturbed for 24 hours, the surface shall show no white, milky colored substance but shall be a homogenous brown color throughout.
- c. The emulsions shall be according to the following requirements when tested according to AASHTO T 59.

	CRSP	HFP
Viscosity, Saybolt Furol, at 122 °F (50 °C), SFS	100-400	50 min.
Storage Stability Test, 24 hours, % ^{1/}	1 max.	1 max.
Particle Charge Test	Positive	N/A
Sieve Test, No. 20 (850 µm), retained on sieve, %	0.1 max.	0.1 max.
Demulsibility, 0.02N CaCl ₂ , %	N/A	30 min.
Distillation Test Residue from distillation test to 374 ± 9 °F (190 ± 5 °C), % Oil distillate by volume, %	65 min. 3 max.	65 min. 3 max.

- d. The Tests on Residue from Distillation shall be according to the following.

	CRSP	HFP
Penetration, 77 °F (25 °C), 100 g, 5 sec., (AASHTO T 49), dmm	100-200	100-200
Ductility, 39.2 °F (4 °C), (AASHTO T 51), mm	300 min.	300 min.
Elastic Recovery, (AASHTO T 301), 39.2 °F (4 °C), %	50 min.	50 min.
Float test at 140 °F (60 °C), (AASHTO T 50), sec	N/A	1200 min.

The different grades are, in general, used for the following.

Grade	Use
SS-1, SS-1h, CSS-1, CSS-1h, HFE 90, SS-1hP, CSS-1hP	Tack or fog seal
PEP	Bituminous surface treatment prime
RS-2, HFE 90, HFE 150, HFE 300, CRSP, HFP, CRS-2, HFRS-2	Bituminous surface treatment
CSS-1h Latex Modified	Microsurfacing

1032.07 Rapid Curing Liquid Asphalt. Rapid curing liquid asphalt will be accepted according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Cutback Asphalt and Road Oil Acceptance Procedure". This material shall be a rapid curing cutback asphalt consisting of a petroleum residuum fluxed with a suitable distillate. The liquid asphalt shall be free from water, show no separation on standing, and shall be according to the requirements listed in the following table.

Test	Grade RC-70
Viscosity, Kinematic, at 140 °F (60 °C), (AASHTO T 201), cSt (mm ² /s)	70 to 140
Distillation Test: (AASHTO T 78) Distillate, percent by volume of total distillate to 680 °F (360 °C) Distillate to 374 °F (190 °C) Distillate to 437 °F (225 °C) Distillate to 500 °F (260 °C) Distillate to 600 °F (315 °C) Residue from distillation to 680 °F (360 °C), percent volume by difference	10 min. 50 min. 70 min. 85 min. 55 min.
Tests on residue from distillation: Penetration, 77 °F (25 °C), 100 g, 5 sec, (AASHTO T 49), dmm Ductility at 77 °F (25 °C), (AASHTO T 51), mm ^{1/} Solubility in trichloroethylene, (AASHTO T 44), %	80 to 120 1000 min. 99.5 min.

1/ If ductility is less than 1000 mm at 77 °F (25 °C), the material will be acceptable if the ductility is more than 1000 mm at 60 °F (15 °C).

The grade is, in general, used for the following.

Grade	Use
RC-70	Prime coats

1032.08 Medium Curing Liquid Asphalts. Medium curing liquid asphalts will be accepted according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Cutback Asphalt and Road Oil Acceptance Procedure". These materials shall be medium curing cutback asphalts consisting of a petroleum

residuum fluxed with a suitable distillate. They shall be free from water, show no separation on standing, and shall be according to the requirements listed in the following table.

Test	Grades				
	MC-30	MC-70	MC-250	MC-800	MC-3000
Flash Point, (Tag open cup), (AASHTO T 79), °F (°C) ^{1/}	100 min. (38 min.)	100 min. (38 min.)	-- --	-- --	-- --
Flash Point, (Cleveland open cup), (AASHTO T 48), °F (°C)	-- --	-- --	150 min. (65 min.)	150 min. (65 min.)	150 min. (65 min.)
Viscosity, Kinematic, at 140 °F (60 °C), (AASHTO T 201), cSt (mm ² /s)	30 to 60	70 to 140	250 to 500	800 to 1600	3000 to 6000
Distillation Test (AASHTO T 78): Distillate, % by volume of total distillate to 680 °F (360 °C): Distillate to 437 °F (225 °C) Distillate to 500 °F (260 °C) Distillate to 600 °F (315 °C) Residue from distillation to 680 °F (360 °C), % volume by difference	 25 max. 40 to 70 75 to 93 50 min.	 20 max. 20 to 60 70 to 90 55 min.	 10 max. 15 to 55 60 to 87 67 min.	 -- 35 max. 45 to 80 75 min.	 -- 15 max. 15 to 75 80 min.
Tests on residue from distillation: Penetration at 77 °F (25 °C), 100 g, 5 sec, (AASHTO T 49), dmm Ductility at 77 °F (25 °C), (AASHTO T 51), mm ^{2/} Solubility in trichloroethylene, (AASHTO T 44), %	 120 to 250 1000 min. 99.5 min.	 120 to 250 1000 min. 99.5 min.	 120 to 250 1000 min. 99.5 min.	 120 to 250 1000 min. 99.5 min.	 120 to 250 1000 min. 99.5 min.

1/ Flash point by Cleveland open cup may be used for products having a flash point greater than 175 °F (80 °C).

2/ If ductility is less than 1000 mm at 77 °F (25 °C), the material will be acceptable if the ductility is more than 1000 mm at 60 °F (15 °C).

The different grades are, in general, used for the following.

Grade	Use
MC-30 and MC-70	Prime coats
MC-250, MC-800 and MC-3000	Surface treatments and seal coats

1032.09 Slow Curing Liquid Asphalts. Slow curing liquid asphalts will be accepted according to the current Bureau of Materials and Physical Research's Policy Memorandum, "Cutback Asphalt and Road Oil Acceptance Procedure". These materials shall be slow curing liquid asphalts produced by the distillation of petroleum. The liquid asphalts shall be residues, distillates, or residues fluxed to the desired consistency with petroleum distillates. Each shipment of liquid asphalt shall be uniform in appearance and consistency. All grades shall be free from water and shall not foam when heated to 225 °F (107 °C). The residues of specified penetration shall be smooth and homogeneous in appearance. This material shall be according to the requirements listed in the following table.

Test	Grades			
	SC-70	SC-250	SC-800	SC-3000
Flash Point, Cleveland open cup, (AASHTO T 48), °F (°C)	150 min. (65 min.)	175 min. (80 min.)	200 min. (93 min.)	225 min. (107 min.)
Viscosity, Kinematic, at 140 °F (60 °C), (AASHTO T 201), cSt (mm ² /s)	70 to 140	250 to 500	800 to 1600	3000 to 6000
Residue of 100 penetration, (ASTM D 243), %	50 min.	60 min.	70 min.	80 min.
Ductility at 77 °F (25 °C), of residue of specified penetration, (AASHTO T 51), mm ^{1/}	1000 min	1000 min	1000 min	1000 min.
Loss on heating at 325 °F (163 °C), 50 g, 5 hours, (AASHTO T 47), %	11 max.	8 max.	5 max.	4 max.
Solubility in trichloroethylene, (AASHTO T 44), %	99.0 min.	99.0 min.	99.0 min.	99.0 min.

1/ If ductility is less than 1000 mm at 77 °F (25 °C), the material will be acceptable if the ductility is more than 1000 mm at 60 °F (15 °C).

The different grades are, in general, used for the following.

Grade	Use
SC-70	For dust layer and for prime coats
SC-250	For road mix and traveling plant mix surfaces dense-graded aggregate type
SC-800	For plant mix surfaces dense-graded aggregate type
SC-3000	Surface treatments and seal coats

1032.10 Road Oils. Road oils will be accepted according to the latest revision of the Bureau of Materials and Physical Research's Policy Memorandum, "Cutback Asphalt and Road Oil Acceptance Procedure". These materials shall be slow curing asphaltic oils. They shall show no separation on standing and shall be according to the requirements listed in the following table.

Test	Grades		
	E-2 Light	E-3 Medium	E-4 Heavy
Water, by volume, percent	0.5 max.	0.5 max.	0.5 max.
Flash Point, Cleveland open cup, (AASHTO T 48) °F (°C)	200 min. (93 min.)	200 min. (93 min.)	200 min. (93 min.)
Viscosity, Kinematic, at 122 °F (50 °C), (AASHTO T 201), cSt (mm ² /sec).	168 to 285	285 to 510	510 to 785
Viscosity, Saybolt Furol, at 122 °F (50 °C), (AASHTO T 59), SFS	80 to 135	135 to 240	240 to 370
Solubility in trichloroethylene, (AASHTO T 44), %	99.5 min.	99.5 min.	99.5 min.
Residue of 100 penetration, ASTM D 243, %	50 min.	55 min.	60 min.
Ductility at 77 °F (25 °C), (AASHTO T 51), of residue of specified penetration, mm	1000 min.	1000 min.	1000 min.

The different grades are used for surface treatment of earth roads.

1032.11 Asphalt Fillers (Prepared from Petroleum). These materials shall be free from water and shall not foam when heated to the flash point. They shall be according to the requirements listed in the following table.

Test	Grades			
	PAF-1	PAF-2	PAF-3	PAF-4
Flash Point, Cleveland open cup, (AASHTO T 48), °F (°C)	450 min. (232 min.)	450 min. (232 min.)	450 min. (232 min.)	475 min. (246 min.)
Softening Point, ring and ball method, (AASHTO T 53), °F (°C)	122 min. (50 min.)	135 min. (57 min.)	167 to 185 (75 to 85)	180 min. (82 min.)
Penetration at 32 °F (0 °C), 200g, 60 sec	30 min.	15 min.	10 min.	15 min.
Penetration at 77 °F (25 °C), (AASHTO T 49), 100g, 5 sec	80 to 100	40 to 55	25 to 40	30 to 50
Penetration at 115 °F (46.1 °C), 50g, 5 sec	--	190 max.	90 max.	80 max.
Loss on heating at 325 °F (163 °C), 50 g, 5 hrs., (AASHTO T 47), %	1.0 max.	1.0 max.	1.0 max.	1.0 max.
Penetration at 77 °F (25 °C), 100 g, 5 sec, of asphalt after heating at 325 °F (163 °C), as compared with penetration of asphalt before heating, %	70.0 min.	70.0 min.	70.0 min.	70.0 min.
Ductility at 77 °F (25 °C), (AASHTO T 51), mm	400 min.	150 min.	25 min.	25 min.
Bitumen soluble in trichloroethylene, (AASHTO T 44), %	99.0 min.	99.0 min.	99.0 min.	99.0 min.

The different grades are, in general, used for the following.

PAF-1 & PAF-2	For filling cracks in portland cement concrete pavement.
PAF-3	For sealing expansion and contraction joints in portland cement concrete pavement and for undersealing portland cement concrete pavement.
PAF-4	For sealing expansion and contraction joints in portland cement concrete pavement and for filler in brick pavement.

MASONRY AND DRAINAGE ITEMS**SECTION 1040. DRAIN PIPE, TILE, DRAINAGE MAT, AND WALL DRAIN**

1040.01 Drain Tile. Drain tile shall be according to the requirements of ASTM C 4. The tile furnished shall be that designated as heavy-duty drain tile. The maximum length of the units shall be 24 in. (600 mm).

1040.02 Clay Pipe. Extra strength clay pipe, extra strength perforated clay pipe, and clay sewer pipe shall be according to the requirements of ASTM C 700.

1040.03 Polyvinyl Chloride (PVC) Pipe. Acceptance testing of PVC pipe and fittings shall be accomplished during the same construction season in which they are installed. The section properties shall be according to AASHTO's Section 17 and the manufacturer shall submit written certification that the material meets AASHTO's Section 17 properties, except for perforated PVC pipe and perforated corrugated PVC pipe with a smooth interior. The pipe shall meet the following additional requirements.

- (a) PVC Pipe. The pipe shall be according to AASHTO M 278 or ASTM F 679, except it shall be made of PVC plastic having a minimum cell classification of 12454-C or 12364-C, as defined in ASTM D 1784.
- (b) Perforated PVC Pipe. The pipe shall be according to AASHTO M 278, except it shall be made of PVC plastic having a minimum cell classification of 12454-C or 12364-C according to ASTM D 1784. Four rows of perforations at 2 in. (50 mm) centers may be used for 12 in. (300 mm) and 15 in. (375 mm) diameter pipes.
- (c) Perforated Corrugated PVC Pipe with A Smooth Interior. The pipe shall be according to ASTM F 949. In addition, the top centerline of the pipe shall be marked so that it is readily visible from the top of the trench before backfilling, and the upper ends of the slot perforations shall be a minimum of ten degrees below the horizontal.
- (d) Corrugated PVC Pipe with a Smooth Interior. The pipe shall be according to ASTM F 949.
- (e) PVC Profile Wall Pipe-794. The pipe shall be according to ASTM F 794 and have a minimum pipe stiffness of 46 psi (317 kPa).
- (f) PVC Profile Wall Pipe-304. The pipe shall be according to AASHTO M 304.

1040.04 Polyethylene (PE) Pipe. Storage and handling shall be according to the manufacturer's recommendations, except in no case shall the pipe be exposed to direct sunlight for more than six months. Acceptance testing of the pipe shall be accomplished during the same construction season in which it is installed. The pipe shall meet the following additional requirements.

- (a) Corrugated PE Pipe, Perforated Corrugated PE Pipe, Corrugated PE Pipe with a Smooth Interior, and Perforated Corrugated PE Pipe With a Smooth

Interior. The pipe shall be according to AASHTO M 252 (nominal size – 3 to 10 in. (75 to 250 mm)). When used for underdrains, the pipe shall have a minimum pipe stiffness of 46 psi (317 kPa) at five percent deflection and shall be capable of 60 percent vertical deflection in parallel plate loading without splitting or cracking.

Fabric envelope materials for perforated pipe shall be stored in UV-resistant bags until just prior to installation.

- (b) Corrugated PE Pipe with a Smooth Interior. The pipe shall be according to AASHTO M 294 (nominal size – 12 to 48 in. (300 to 1200 mm)). The pipe shall be Type S or D.
- (c) PE Profile Wall Pipe. The pipe shall be according to ASTM F 894 and the following.
 - (1) Pipe Culverts and Storm Sewers. When used for pipe culverts and storm sewers, the section properties shall be according to AASHTO's Section 17 and the pipe shall have a minimum ring stiffness constant of 160. The manufacturer shall submit written certification that the material meets AASHTO's Section 17 properties.
 - (2) Insertion Lining. When used for insertion lining of pipe culverts, the pipe liner shall have a minimum pipe stiffness of 46 psi (317 kPa) at five percent deflection for nominal inside diameters of 42 in. (1050 mm) or less. For nominal inside diameters of greater than 42 in. (1050 mm), the pipe liner shall have a minimum pipe stiffness of 32.5 psi (225 kPa) at five percent deflection. All sizes shall have wall construction that presents essentially smooth internal and external surfaces.
- (d) PE Pipe with a Smooth Interior. The pipe shall be according to ASTM F 714 (DR 32.5) with a minimum cell classification of PE 335434 as defined in ASTM D 3350. The section properties shall be according to AASHTO's Section 17. The manufacturer shall submit written certification that the material meets AASHTO's Section 17 properties and the resin used to manufacture the pipe meets or exceeds the minimum cell classification requirements.

1040.05 Reinforced Plastic Mortar (RPM) Pipe. The pipe shall be according to ASTM D 3262 and shall have approved inverted bell and spigot joints with elastomeric seals according to ASTM F 477.

1040.06 Drainage Mat Underdrain. Drainage mat underdrain shall be on the Department's approved list.

Drainage mat underdrain shall be a flexible rectangular hollow mat consisting of a supporting drainage core of the width shown on the plans and a nominal thickness of 1.0 in. (25 mm), encased in and/or bonded to an approved geotechnical fabric envelope weighing not less than 4.0 oz/sq yd (135 g/sq m) fitting snugly around the core. The flow rate of the core shall be not less than 16 gal/min (60 L/min) at a hydraulic gradient of 0.1, 1.20 in. (30 mm) of total head, nominal width and length of 12 in. (300 mm) per specimen, when subjected to a normal stress of 30 psi (200 kPa)

according to ASTM D 4716. Closed-cell foam rubber layers shall be used to model soil adjacent on both sides of the specimen. The compressive strength of the drainage mat underdrain shall be a minimum of 4500 lb/sq ft (215 kPa) with a maximum deflection of 20 percent, when tested between parallel plates according to ASTM D 695 (D 695M) with the modification of 1/4 in. (6 mm) thick rubber cushions having standard hardness of 80 ± 10 Shore A Durometer above and below the specimen.

The drainage core shall be fabricated of polyethylene with a minimum cell classification of PE 112110 or better according to ASTM D 3350, or of PVC 12353 C or better according to ASTM D 1784, or other approved material. Drainage mat underdrain shall be furnished with approved fittings to connect with the type of pipe underdrain (special) used.

The manufacturer of the drainage mat underdrain shall certify that the flow rate specified according to ASTM D 4716 is met and the resin used to manufacture the drainage core meets or exceeds the minimum cell classification requirements.

1040.07 Geocomposite Wall Drain. Geocomposite wall drain shall be a flexible geocomposite consisting of a supporting structure or core, the soil side of which is bonded to an approved geotextile weighing not less than 3.5 oz/sq yd (120 g/sq m). The drainage core shall provide support to and be bonded to the geotextile at intervals not exceeding 1 1/8 in. (30 mm) in any direction, and shall permit unobstructed flow through not less than 75 percent of the geotextile.

The flow rate of the core shall not be less than 10 gal/min/ft (125 L/min/m) at a hydraulic gradient of 1.0 when subjected to a normal pressure on the soil side face of 6,000 lb/sq ft (285 kPa). When tested in a sand box according to the Department's method at 6,000 lb/sq ft (285 kPa), the core deflection shall not exceed 20 percent.

The core shall be fabricated of polyethylene with a minimum cell classification of PE 112110 according to ASTM D 3350 or other approved material.

The wall drain shall be furnished with: 1) approved fittings to connect with outlet pipes and weep holes; 2) suitable approved splices; 3) end, top, and bottom caps to prevent the intrusion of backfill material into the core; and 4) approved fastening systems to secure the wall drain to the wall.

SECTION 1041. BUILDING BRICKS AND PAVING BRICKS

1041.01 Building Brick (Made from Clay or Shale). Building brick, made from clay or shale, shall be according to the requirements of AASHTO M 114. The brick shall be of the grade designated as Grade SW.

1041.02 Reserved.

1041.03 Paving Brick. Paving brick shall be made from clay or shale and shall be according to the following.

- (a) Sidewalk and Light Vehicular Traffic. Paving brick for sidewalk and light vehicular traffic shall be Class SX, Type 1 according to ASTM C 902.

- (b) Heavy Vehicular Traffic. Paving brick for heavy vehicular traffic shall be according to ASTM C 1272.

For ASTM C 902 and ASTM C 1272, satisfactory, in-service performance will not be accepted as a means to waive physical test requirements.

SECTION 1042. PRECAST CONCRETE PRODUCTS

1042.01 Description. This item shall consist of the manufacture and shipping of precast concrete products.

CONSTRUCTION REQUIREMENTS

1042.02 General. Precast concrete products shall be according to the current Bureau of Materials and Physical Research's Policy Memorandum "Quality Control/Quality Assurance Program for Precast Concrete Products".

The reinforcement bars used in precast concrete products shall be according to Article 1006.10(a).

Precast concrete structural members, precast concrete piles, precast concrete headwall for pipe drain, precast concrete right-of-way markers, precast concrete drainage markers, precast concrete permanent survey markers, precast concrete section markers, and precast temporary concrete barrier shall be wet cast only.

When a precast product has attained the specified strength, the earliest the product may be loaded, shipped, and used is on the fifth calendar day. The first calendar day shall be the date casting was completed.

Construction requirements for reinforcement bars shall be according to Section 508.

1042.03 Precast Concrete Structural Members (Section 504). Bridge slabs, pile caps, and other structural members shall be according to the following.

- (a) The concrete shall be Class PC according to Section 1020, and shall have a minimum compressive strength of 4500 psi (31,000 kPa) at 28 days.
- (b) Shop Drawings. Before fabrication begins, the Contractor shall submit duplicate prints of shop drawings to the Engineer for review and preliminary approval. Discrepancies in the contract plans or existing conditions discovered during preparation of the shop drawings shall be reported to the Engineer for resolution prior to submitting the shop drawings for review and approval. These drawings shall be on full size sheets, 22 x 34 in. (550 x 850 mm) or reduced size sheets, 11 x 17 in. (275 x 425 mm). Each full or reduced size sheet shall provide adequate space for review and approval stamps at the lower right hand corner. Both lettering and details shall ensure legibility for review and reproduction after microfilming. All drawings shall be completely titled according to the contract plans including structure number, state contract number, route, section, and county, and

shall pertain to only one structure. If the submitted shop drawings have significant discrepancies, revised sets shall be submitted until details comply with the contract requirements. After all review comments have been addressed and preliminary approval is given, the Contractor shall furnish six or more full or reduced size prints of the drawings as directed by the Engineer, and these shall be distributed and become a part of the contract. Changes to previously approved shop drawings shall be subject to the approval of the Engineer, and the Engineer shall be supplied with a record of all such changes.

After the Engineer's preliminary approval and prior to distribution, prints of shop drawings for structures that carry railroad traffic shall also be submitted for the approval of the Railroad Engineer. Upon request, the Contractor shall also furnish full size reproduces, 22 x 34 in. (550 x 850 mm), including margins. The margin at the left end shall be 1 1/2 in. (40 mm) and the others 1/2 in. (13 mm) wide. These reproduces shall become the property of, and shall be delivered to, the Railroad upon completion of the contract.

All modifications based on department-permitted alternatives, such as altered reinforcement geometry, or size and spacing, shall be summarized and the list included with the initial review submittal.

(c) Forms. Forms shall be according to Article 503.06.

(d) Reinforcement and Accessories. Welding will be permitted where approved by the Engineer. The concrete cover over all reinforcement shall be within $\pm 1/4$ in. (± 6 mm) of the specified cover.

Welded wire fabric shall be accurately bent and tied in place. Welding will be permitted where approved by the Engineer.

Miscellaneous accessories to be cast into the concrete or for forming holes or recesses shall be carefully located and rigidly held in place by bolts, clamps, or other effective means. If paper tubes are used for vertical dowel holes, or other vertical holes which require grouting, they shall be removed before transportation to the construction site.

(e) Manufacturing. Manufacturing shall be according to the following.

(1) The roadway surface of bridge slabs shall be finished with a float and the exposed face and top of curb section shall be finished according to Article 503.15(a).

(2) Side forms may be removed when no distortion, slump, or misalignment of the concrete will be caused.

(3) The units shall remain on the bottom supporting forms until the concrete has attained a compressive strength of not less than 2000 psi (14,000 kPa).

- (4) If unsatisfactory compression strength test results are obtained, cores for additional tests may be taken if approved by the Engineer.
- (5) Tolerance of Dimensions. The four sides of the members shall not vary more than 1/8 in. (3 mm) for the full depth of the member when tested with a straightedge in a vertical direction, nor more than 1/4 in. (6 mm) in the full length of the member when tested with a straightedge in a horizontal direction; nor shall the surface of the member deviate more than 1/8 in. (3 mm) from a straight line 10 ft (3 m) long connecting two points on the member's surface.
- (6) Handling. The members shall be handled in a manner that will not cause crushing, spalling or undue marring of the concrete. The ends of precast members shall not be permitted to extend a distance exceeding the depth of the member on any vehicle, bolster, or other point of bearing during hauling or stockpiling.

Precast members shall be handled with a suitable hoisting device or crane provided with a spreader sling of sufficient capacity to handle the members. The spreader shall be of sufficient length to prevent horizontal forces in the member due to lifting, and shall be equipped with leads and hooks at each end. For the purpose of engaging the threaded inserts provided in the member, the manufacturer shall provide a sufficient number of eye bolts of proper size.

Before lifting the member, all lifting inserts in each end shall be fully engaged with the spreader lead hooks. In the event that raising by alternate lifting and blocking of opposite ends is performed, the lifted end shall not be rotated unless a proper pivoting device for the opposite end has been provided.

1042.04 Precast Concrete Piles and Extensions (Section 512). Precast concrete piles and extensions shall be according to Articles 1042.03(a)(b)(c)(d)(e) and the following.

After removal of the side forms, the entire pile shall be supported and shall not be handled until the specified strength is obtained.

The maximum allowable deviation of the longitudinal axis from a straight line drawn from the center of the tip to the center of the butt shall not exceed 1/4 in. per 25 ft (6 mm per 7.6 m) of length of the pile.

1042.05 Precast Concrete Box Culverts (Section 540). Precast concrete box culverts shall be according to Articles 1042.03(c)(d)(e) and the following additional requirements.

- (a) The concrete shall be Class PC according to Section 1020, and shall have a minimum compressive strength per ASTM C 1577.
- (b) Precast concrete box culvert sections and end sections shall be according to the requirements of ASTM C 1577 for the design cover specified but limited to maximum design covers shown in the tables.

1042.06 Precast Concrete Pipe (Sections 542, 550, 551, 552, and 601).

Precast concrete pipe shall be according to Articles 1042.03(c)(d)(e). Class PC concrete shall not apply. The concrete mix design specifications and material proportions shall be determined by the Contractor. Before the work begins, the concrete mix design specifications, material proportions, and aggregate gradations shall be approved by the Engineer.

The pipe strength shall be per AASHTO, except drain tile shall have a minimum crushing strength of 1400 lb/ft (20.5 kN/m). Pipe shall be according to the following additional requirements.

- (a) Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe. These pipes, elbows, and tees shall be according to AASHTO M 170 (M 170M) Classes I to V, Tables 1 to 5, except that the use of elliptical reinforcement in circular pipe will not be permitted. The mortar used in the fabrication of elbows and tees shall be a packaged rapid hardening mortar or nonshrink grout according to Sections 1018 and 1024, respectively.
- (b) Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe. Pipes shall be according to AASHTO M 207 (M 207M).
- (c) Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe. Pipes shall be according to AASHTO M 206 (M 206M).
- (d) Concrete Sewer, Storm Drain, and Culvert Pipe. Pipes shall be according to AASHTO M 86 (M 86M).
- (e) Concrete Drain Tile. Drain tiles shall be according to AASHTO M 178 (M 178M).

1042.07 Precast Reinforced Concrete Flared End Sections (Section 542).

Precast reinforced concrete flared end sections shall be according to Articles 1042.03(c)(d)(e). Class PC concrete shall not apply. The concrete mix design specifications and material proportions shall be determined by the Contractor. Before the work begins, the concrete mix design specifications, material proportions, and aggregate gradations shall be approved by the Engineer.

The end section strength shall be per AASHTO, and the following additional requirements.

- (a) Circular pipe. The end section shall be according to AASHTO M 170 (M 170M) for Class III, Wall B reinforced concrete pipe.
- (b) Elliptical pipe. The end section shall be according to AASHTO M 207 (M 207M) for Class HE-II reinforced concrete pipe.

1042.08 Precast Concrete Inlet Boxes for Pipe Culverts and Medians (Section 542). Precast inlet Boxes Types 24A, 24B, 24C, 24D, 24E, 24F, 24G, 36A, 48A, and Flush Inlet Box for Medians shall be according to Articles 1042.03(a)(c)(d)(e).

1042.09 Precast Concrete Headwall for Pipe Drain (Section 601). Concrete headwall for pipe drain shall be Class PC concrete according to Section 1020 with a minimum compressive strength of 4000 psi (28,000 kPa) at 28 days, and shall be according to Articles 1042.03(c)(d)(e).

1042.10 Precast Concrete Catch Basins, Manholes, Inlets, Drainage Structures, and Valve Vaults (Sections 602 and 603). Precast concrete catch basins, manholes, inlets, drainage structures, and valve vaults shall be according to Articles 1042.03(c)(d)(e). Class PC concrete shall not apply. The concrete mix design specifications and material proportions shall be determined by the Contractor. Before the work begins, the concrete mix design specifications, material proportions, and aggregate gradations shall be approved by the Engineer.

Catch Basin Types A, B, C, and D; Manhole Type A; Inlet Types A and B; Drainage Structures Types 1, 2, 3, 4, 5, and 6; Valve Vault Type A; and reinforced concrete flat slab top (Highway Standard 602601) shall be according to AASHTO M 199 (M 199M), except the minimum wall thickness shall be 3 in. (75 mm) and the minimum compressive strength shall be 4500 psi (31,000 kPa) at 28 days. However, if the Manhole Type A is 7, 8, or 9 ft (2.1, 2.4, or 2.7 m) in diameter, the manhole, bottom slab, and flat slab top shall have a minimum compressive strength of 5000 psi (34,500 kPa) at 28 days.

1042.11 Precast Concrete Bridge Approach Drains (Section 609). Bridge Approach Shoulder Pavement and Drain, and Bridge Approach Pavement (Drain Detail) shall be according to Articles 1042.03(a)(c)(d)(e).

1042.12 Precast Concrete Shoulder Inlet (Section 610). Shoulder Inlet with Curb shall be according to Articles 1042.03(a)(c)(d)(e).

1042.13 Precast Concrete Right-of-Way Markers, Drainage Markers, Permanent Survey Markers, and Section Markers (Sections 666 and 667). Right-of-way markers, drainage markers, permanent survey markers, and section markers shall be Class PC concrete according to Section 1020 with a minimum compressive strength of 3500 psi (24,000 kPa) at 14 days, and shall be according to Articles 1042.03(c)(d)(e).

1042.14 Precast Temporary Concrete Barrier (Section 704). Temporary concrete barrier shall be Class PC concrete according to Section 1020 with a minimum compressive strength of 4000 psi (27,500 kPa) at 28 days, and shall be according to Articles 1042.03(c)(d)(e).

1042.15 Precast Concrete Block, Brick, Masonry Units, and Pavers. Class PC concrete shall not apply. The concrete mix design specifications and material proportions shall be determined by the Contractor. Before the work begins, the concrete mix design specifications, material proportions, and aggregate gradations shall be approved by the Engineer.

The block, brick, masonry unit, and paver strength shall be per ASTM, and the following additional requirements.

- (a) Concrete Block for Erosion Control (Section 285). The block shall be according to ASTM D 6684. Freeze/thaw durability shall be determined

according to ASTM C 67 or ASTM C 1262. The freeze thaw criteria shall be as follows.

- (1) ASTM C 67. Specimens shall have no breakage and 1.0 percent or less loss in dry weight (mass) of any individual unit when subjected to 50 cycles of freezing and thawing.
- (2) ASTM C 1262. Specimens shall comply with either of the following.
 - a. The weight (mass) loss of each of five test specimens at the conclusion of 100 cycles shall not exceed 1.0 percent of its initial weight (mass).
 - b. The weight (mass) loss of each of four of the five test specimens at the conclusion of 150 cycles shall not exceed 1.5 percent of its initial weight (mass).
- (b) Concrete Brick (Sections 602, 603 and 605). Concrete brick shall be according to ASTM C 55.
- (c) Concrete Masonry Units (Sections 602 and 603). Solid concrete masonry units shall be according to ASTM C 139. Hollow load-bearing concrete masonry units shall be according to ASTM C 90.
- (d) Concrete Pavers. Concrete pavers shall be according to ASTM C 936, except proof of resistance to freezing and thawing shall be according to ASTM C 1645 (saline test solution).

1042.16 Handling Hole Plugs. Plugs for handling holes in precast concrete products shall be as follows.

- (a) Precast Concrete Plug. The precast concrete plug shall have a tapered shape and shall have a minimum compressive strength of 3000 psi (20,700 kPa) at 28 days.
- (b) Polyethylene Plug. The polyethylene plug shall have a “mushroom” shape with a flat round top and a stem with three different size ribs. The plug shall fit snugly and cover the handling hole.

The plug shall be according to the following.

Mechanical Properties	Test Method	Value (min.)
Flexural Modulus	ASTM D 790	3300 psi (22,750 kPa)
Tensile Strength (Break)	ASTM D 638	1600 psi (11,030 kPa)
Tensile Strength (Yield)	ASTM D 638	1200 psi (8270 kPa)

Thermal Properties	Test Method	Value (min.)
Brittle Temperature	ASTM D 746	-49 °F (-45 °C)
Vicat Softening Point	ASTM D 1525	194 °F (90 °C)

SECTION 1043. ADJUSTING RINGS**1043.01 Reserved.**

1043.02 High Density Polyethylene (HDPE) Plastic Adjusting Rings. HDPE plastic adjusting rings shall be manufactured from Class B HDPE plastic, as identified in ASTM D 1248, using the injection molding process. They shall be designed and tested to meet or exceed an HS25 wheel load according to the AASHTO Standard Specifications for Highway Bridges and shall be stabilized against the effects of ultraviolet light.

Recycled material may be used. If recycled material is used, only polyethylene and less than two percent polypropylene will be allowed in the reclaim process. All feed stock shall be tested by the manufacturer on a procurement/production batch basis to verify the following property values.

Physical Property	Test Standard	Value
Melt Flow Index	ASTM D 1238	0.01 to 1.06 oz/10 min (0.30 to 30.0 g/10 min)
Specific Gravity	ASTM D 792	0.84 to 0.98
Tensile Strength, Yield	ASTM D 638	2000 psi (13,800 kPa) minimum

HDPE plastic adjusting rings shall have no void areas, cracks, or tears, and have no effects due to exposure to ultraviolet light. Ripples or sags shall be limited to less than ten percent of the surface. The actual diameter or length shall not vary more than 0.125 in. (3 mm) from the specified diameter or length. Variations in height are limited to ± 0.063 in. (1.6 mm) for parts up to 2 in. (50 mm) or ± 0.125 in. (3 mm) for parts from 2 in. (50 mm) to 3 in. (75 mm). Variations shall not exceed 0.25 in. (6 mm) from flat (dish, bow or convoluting edge) or 0.125 in. (3 mm) for bulges or dips in the surface.

1043.03 Recycled Rubber Adjusting Rings. Recycled rubber products shall consist of no less than 80 percent by weight recycled rubber. The riser shall meet or exceed the following when maintained at 73 ± 3 °F (23 ± 2 °C) for at least 24 hours prior to and during testing.

Physical Property	Test Standard	Value
Density	ASTM C 642	68.63 ± 2.11 lb/cu ft (1.10 ± 0.034 g/cu cm)
Durometer Hardness	ASTM D 2240 Shore A	72 ± 6 ^{1/}
Compression Deformation under 145 psi (1000 kPa)	ASTM D 575 – Test Method B Test of Specified Force	9 ± 4 %
Compression Set	ASTM D 395 – Illinois Modified Test Method B Compression Set under Constant Deflection in Air	5 ± 3 % ^{2/}
Weathering (70 hrs at 158 °F (70 °C)) Hardness retained	ASTM D 573	98 %, minimum
Freeze/thaw when exposed to deicing chemicals	ASTM C 672	3 % loss, maximum

1/ Average of three tests over a 1.12 in. (28 mm) diameter sample.

2/ Samples compressed to 75 percent of initial height.

Recycled rubber adjusting rings shall have no void areas, cracks, or tears, and have no defects due to exposure to ultraviolet light. The actual diameter or length shall not vary more than 0.125 in. (3 mm) from the specified diameter or length. Variations in height are limited to ± 0.063 in. (1.6 mm) for parts up to 2 in. (50 mm).

SECTION 1044. FLAP GATE

1044.01 Cover. The cover shall be cast iron, ASTM A 126, Class B, with necessary reinforcing ribs. It shall be fabricated with a lifting eye for manual operation, and with bosses to provide a pivot point connection with the links. Bosses shall be designed to place the hinge bolt in double shear when the gate is assembled. Pivot bosses shall be designed to limit the double hinge action, preventing the cover from rotating sufficiently to become wedged in the open position.

1044.02 Frame. The one-piece cast iron frame shall be according to requirements of ASTM A 126, Class B.

The frame shall have a raised section around the perimeter of the waterway opening to provide the seating face. The raised section shall provide a seating plane diverging, top to bottom, from the plane of the mounting flange to assist in a positive closure of the cover.

The frame shall be flat back or spigot back as designated on the plans. The spigot back gates shall be designed for attaching to corrugated steel pipe.

1044.03 Seating Faces. The cast iron seating faces on the seat and the cover shall be machined to a plane with a minimum 63 micro in. (1.6 μ m) finish.

The seating faces may be bronze according to the requirements of ASTM B 21 (B 21M) - C48200 and shall be pneumatically impacted into dove-tailed grooves machined to 63 micro in. (1.6 μ m) finish for maximum water tightness. Resilient seat, neoprene or Buna-N, when specified, shall be bonded in a groove machined in the frame to provide a wide seating surface for the seating face machined on the cover.

1044.04 Top Pivot Connection. The top connections to the hinge links or arms shall be with pivot lugs or some other system which has double bosses to place the top hinge bolts in double shear when they are assembled through the links or arms. The connections shall be adjustable in the horizontal plane without removal of the cover from the gate links or arms. The adjustment shall allow the top pivots to be moved toward the gate seat for reduced sensitivity of the cover, or moved away from the gate seat, to provide opening with a minimum differential head.

1044.05 Hinge Links or Arms. The hinge arms connecting the cover and pivot lugs shall be high-tensile bronze, ASTM B 584-C86500, one-piece heavy duty cast iron, ASTM A 126, Class B, or high strength ductile iron, ASTM A 536, Gr. 65-45-12.

Each hinge link or arm shall have two pivot points, an adjustable lower pivot with limited rotation and a threaded upper hinge post to adjust flap gate sensitivity.

The bottom of the links or arms shall be provided with an adjusting screw to properly align seating faces on the cover with respect to the seat. The links or arms shall be designed to limit the double hinge action, preventing the cover from rotating sufficiently to become wedged in the open position.

Cast iron or ductile iron links or arms shall be provided with a commercial grade bronze bushing at each pivot point. The hinge pins designed in double shear shall be bronze, ASTM B 98 (B 98M) - C65500 or Type 304 stainless steel.

1044.06 Fasteners. All anchor bolts, screws, and nuts shall meet the requirements of ASTM A 307, and be of ample section to safely withstand the forces created by the operation shown on the manufacturer's gate schedule. The anchor bolts, screws, and nuts shall be galvanized according to ASTM B 633.

1044.07 Painting. All cast iron parts shall be grit-blast cleaned to base metal before painting. All ferrous parts of the flap gates shall be painted with a prime coat and shop coat. The paint shall be applied according to the manufacturer's standard practice.

All machined surfaces shall be coated with a water-resistant rust preventive coating.

FILLERS, SEALERS, AND WATERPROOFING ITEMS**SECTION 1050. POURED JOINT SEALERS**

1050.01 Cold-Poured Joint Sealer. Cold-poured joint sealer, cold application type shall be according to ASTM D 1850-74.

1050.02 Hot-Poured Joint Sealer. Hot-poured joint sealer shall be according to ASTM D 6690, Type II.

1050.03 Polysulfide Joint Sealant. The joint sealant shall be a polysulfide, Type S or Type M, Grade NS, Class 25 or 12 1/2, Use T, according to ASTM C 920.

SECTION 1051. PREFORMED EXPANSION JOINT FILLERS

1051.01 Methods of Sampling. Two samples, each 12 in. (300 mm) in length and full width, will be taken for each 1000 ft (300 m) or fraction thereof. Individual samples will be taken from separate pieces of preformed expansion joint filler selected at random.

1051.02 Methods of Testing. In addition to Article 106.03, preformed expansion joint fillers will be tested as follows.

Extraction of Asphalt. The asphalt will be extracted by means of a Soxhlet extraction apparatus (large), equipped with a glass extraction shell having a round, perforated bottom. A small quantity of glass wool will be placed in the bottom of the extraction shell. Trichloroethylene shall be used as the extracting solvent. A sample weighing approximately 45 g will then be cut into narrow strips and packed in the shell above the glass wool. The residue in the shell, after complete extraction of the bitumen, will be thoroughly dried at a temperature of $215 \pm 5^{\circ}\text{F}$ ($102 \pm 3^{\circ}\text{C}$), cooled, weighed, and the percent of bitumen determined by difference. Before extraction, the sample shall be dried for 3 hours in a constant temperature oven at $325 \pm 5^{\circ}\text{F}$ ($163 \pm 3^{\circ}\text{C}$).

1051.03 Bituminous Preformed Joint Filler. Bituminous preformed joint filler shall consist of bitumen, felt, and mineral.

The felt shall be roofing felt produced by the felting of vegetable and animal fibers. The felt shall be free from foreign substances, such as leather, rubber, straw, or wood.

The mineral shall consist of finely crushed slate, limestone, silica, sand, or similar mineral matter.

Roofing scrap may be used in the manufacture of joint filler, provided the quality of felt and mineral are complied with.

The preformed joint filler shall not contain wood in ground form or otherwise, nor coarse fragments of any description, and the presence of straw or cornstalks used as a substitute for felt, or the presence of large particles of slate or other foreign matter will be deemed sufficient cause for rejection.

Bituminous preformed joint filler shall further comply with the requirements of AASHTO M 33, except that the percent of soluble material in the mastic portion will be based on an extraction made in trichloroethylene as specified in Article 1051.02.

1051.04 Preformed Fiber Joint Filler. Preformed fiber joint filler shall comply with the requirements of AASHTO M 213, except that suitable binders other than bituminous will be permitted.

1051.05 Bituminous Preformed Inorganic Fiber Joint Filler. This material shall consist of a preformed strip made from inorganic fibers securely bound together and uniformly impregnated with a suitable bituminous binder. This strip shall be reinforced with a layer of felt paper on each side and shall be according to the requirements of AASHTO M 213, except that the minimum load to compress the material to 50 percent of its thickness before test is waived.

1051.06 Preformed Cork Joint Filler. Preformed cork joint filler shall comply with the requirements of AASHTO M 153, Type II.

1051.07 Preformed Self-Expanding Cork Joint Filler. Preformed self-expanding cork joint filler shall comply with the requirements of AASHTO M 153, Type III.

1051.08 Reserved.

1051.09 Preformed Flexible Foam Expansion Joint Filler. Preformed flexible foam expansion joint filler shall consist of a synthetic foam of isomeric polymers or other approved material in a small closed cell structure. It shall be chemically inert and have no food value that would attract or support plant or animal life. It shall be odorless and nontoxic, shall remain flexible over a wide range of temperatures, shall be compatible with hot-poured joint sealer meeting the requirements of Article 1050.02, and shall have a melting point of 330 °F (165 °C) minimum.

In addition to the above, the filler shall comply with the following requirements.

(a) Physical Properties, ASTM D 545, 1/2 in. (13 mm) test specimen.

- | | |
|--|---|
| (1) Compression at 50 percent deflection | 10 psi (70 kPa) min.
25 psi (170 kPa) max. |
| (2) Extrusion | 0.2 in. (5 mm) max. |
| (3) Recovery | 97 % min. |
| (4) Water absorption, volume | 0.5 % max. |

- (b) **Dimension and Tolerance.** Measurements shall be made on a unit of stock that has been conditioned at a temperature of $75 \pm 7^{\circ}\text{F}$ ($24 \pm 4^{\circ}\text{C}$) for a minimum of 24 hours.

(1) The thickness shall have a tolerance of 1/4 in. (6 mm) and minus 0.

(2) The width shall have a tolerance of $\pm 1/4$ in. (± 6 mm).

(3) The length shall be equal to the lane width of the pavement and shall have a tolerance of $\pm 1/2$ in. (± 13 mm).

- (c) **Appearance**

(1) Each piece of plank shall not contain more than three percent voids or hard spots.

(2) The surface shall be smooth and reasonably free of dents or appendages. All packaged products shall be free of surface dirt and packaging damages.

(3) The planks shall have no kinks or other deformities affecting straightness.

1051.10 Preformed Recycled Rubber Joint Filler. Preformed recycled rubber joint filler shall consist of ground tire rubber, free of steel and fabric, combined with ground scrap or waste polyethylene. It shall not have a strong hydrocarbon or rancid odor and shall meet the physical property requirements of ASTM D 1752. Water absorption by volume shall not exceed 5.0 percent.

SECTION 1052. NEOPRENE EXPANSION JOINT

1052.01 Description. Neoprene Expansion Joint shall consist of molded anchor blocks of elastomeric and steel, field assembled over continuous lengths of elastomeric sealing membrane, with incidental accessories, sealants, and adhesives, as shown on the plans and as specified.

Shop drawings of the details and material of the neoprene expansion joint and incidental accessories, sealants, and adhesives shall be submitted to the Engineer for approval.

1052.02 Materials. The materials for the neoprene expansion joints and accessories shall be according to the following.

- (a) **Elastomeric Materials.** The elastomeric materials of the compounds for anchor blocks and sealing membrane shall be virgin polychloroprene ASTM D 2000, line call-outs 2BC, 515, A14, B14, C12, K11, 21, 22; or ethylene propylene diene monomer (EPDM) ASTM D 1582, line call-outs 3BA, 515, A14, B13, F17, C12, K21, 22 having the following properties.

	ASTM STANDARD	REQUIREMENT
Durometer - Shore A	D 2240	50 min.
Tensile Strength	D 412	1500 psi (10,300 kPa) min.
Ultimate Elongation	D 412	200% min.
Compression Set 22 Hours @ 212 °F (100 °C)(Method "B") for Polychloroprene	D 395	35% Max.
@ 158 °F (70 °C) (Method "B") for EPDM		25% Max.
Low Temperature Brittleness (Method "A")	D 2137	Pass
Non-brittle after 3 min. @ 34 °F (1 °C)		
Ozone Resistance Procedure "B" - D 518 100 PPHM Ozone for 70 Hours @ 100 °F (38 °C)	D 1149	No Cracks
Sample Under 20% Strain Bond During Vulcanization (Method "B")	D 429	80% R

When test specimens are cut from the finished product, a ten percent variation in "Physical Properties" will be allowed.

- (b) Steel reinforcement in anchor blocks. The steel reinforcement in anchor blocks shall be bonded to elastomer during the vulcanization process and shall be according to ASTM A 1011 (A 1011M), Grade 36, SAE 1020, or equal.
- (c) Adhesive and Sealant. The adhesive/sealant bedding compound for bonding the expansion joint seals to the concrete or steel seats shall be a polysulfide grout meeting the requirements of Federal Specification MMM-G-650B, Grade C with 50 percent filler material allowed.

The sealant for sealing between the ends of elastomeric anchor blocks, between edges of concrete block-out and anchor blocks, and for filling bolt hole cavities shall be a one or two part, non-sagging polysulfide or polyurethane black sealing compound meeting the requirements of Federal Specification TT-S-00230C, Type II.

Bedding and sealing compounds that do not meet the specifications shall not be used without prior approval of the Department. Other compounds submitted for approval will be evaluated on their ability to provide equivalent physical and functional properties.

- (d) Anchor Bolts, Threaded Rods, Washers, and Nuts. Anchor bolts, threaded rods, washers, and nuts shall either be stainless steel meeting the requirements of ASTM A 193 (A 193M), Class 2, or shall be according to the requirements of AASHTO M 164 (M 164M), zinc-coated according to Article 1006.08(a).

- (e) Automatically End Welded Threaded Studs, Washers, and Nuts. Automatically end welded threaded studs, washers, and nuts shall be stainless steel meeting the requirements of ASTM A 193 (A 193M). Welding and inspection of the threaded studs shall be according to Article 505.08(m).

1052.03 Certification. The Contractor shall furnish a certification by the manufacturer stating that the neoprene expansion joint and the accessory items meet the requirements approved by the Department. This will not constitute a waiver on the part of the Department of any requirements with respect to samples or samplings, and the right is retained to perform any test deemed by the Department as necessary to qualify the materials.

SECTION 1053. PREFORMED ELASTOMERIC SEALS FOR CONCRETE

1053.01 Preformed Elastomeric Joint Seals For Pavement. Preformed elastomeric joint seals used in pavement shall be according to AASHTO M 220.

The lubricant-adhesive used with the seals shall be according to ASTM D 4070.

1053.02 Preformed Elastomeric Joint Seals For Bridge Decks. Preformed elastomeric joint seals used in bridge decks shall be according to AASHTO M 297.

The lubricant-adhesive used with the seals shall be according to ASTM D 4070.

1053.03 Preformed Elastomeric Strip Seals For Bridge Decks. Preformed elastomeric strip seals shall be according to ASTM D 5973. The seal shall have a shallow “v” profile and shall contain “locking ears” that form a mechanical interlock when inserted in the steel locking edge rails. The size of the seal shall accommodate the rated movement shown on the plans.

The lubricant-adhesive used with the seals shall be according to ASTM D 4070.

SECTION 1054. NONMETALLIC WATER SEALS

1054.01 Description. Nonmetallic water seals shall be either thermoplastic or rubber.

All nonmetallic water seals shall be produced by a process that will provide a dense, homogeneous material free from imperfections. The cross section of the water seal shall be such as to ensure anchorage into the concrete by means of enlarged ends and/or fins and shall be approved by the Engineer. Nonmetallic water seal shall be capable of effectively sealing the joints in concrete against the infiltration of moisture.

1054.02 Polyvinyl Chloride (PVC) Water Seal. The water seal shall be extruded from a specially compounded thermoplastic material consisting of a basic resin of polyvinyl chloride with additional resins, plasticizers, stabilizers, or other ingredient materials needed to provide a satisfactory water seal. Samples taken from the finished water seals shall meet the following requirements.

- (a) Tensile Strength. The tensile strength shall be not less than 1500 psi (10,300 kPa).
- (b) Elongation. The elongation shall be not less than 300 percent.
- (c) Cold Bend. Specimens 1 in. (25 mm) wide and approximately 6 in. (150 mm) long shall be cooled until the material is between 0 and – 10 °F (–18 and –23 °C), then immediately bent 180 degrees around a mandrel 1/4 in. (6 mm) in diameter. The specimens shall show no cracking.
- (d) The material shall have a low water absorption, a high resistance to acids and alkalies, and little deterioration under accelerated aging tests.

1054.03 Rubber Water Seal. The water seal shall consist of natural rubber or a high grade synthetic rubber polymer compounded to produce satisfactory physical properties and aging characteristics. Samples taken from the finished water seals shall be according to the following.

- (a) Tensile Strength. The tensile strength shall be not less than 2500 psi (17,200 kPa).
- (b) Elongation. The elongation shall be not less than 400 percent.
- (c) Hardness. The Shore A Durometer hardness shall be 60 to 70.
- (d) Absorption. The absorption of water by weight shall be not greater than five percent.
- (e) Specific Gravity. The specific gravity shall be 1.15 ± 0.05 .
- (f) Strength After Aging. The tensile strength after the air accelerated aging test of 48 hours in oxygen at 158 °F (70 °C) and 300 psi (2,100 kPa) shall be not less than 80 percent of the original tensile strength.
- (g) Test Methods. Tests will be made according to the following methods.
 - (1) Tensile Strength - ASTM D 412
 - (2) Elongation - ASTM D 412
 - (3) Specific Gravity - ASTM D 297
 - (4) Absorption - ASTM D 570
 - (5) Hardness - ASTM D 2240
- (h) Test Samples. The nonmetallic water seal will be sampled on the job or at the source of supply, as determined by the Engineer. The Contractor shall furnish 18 in. (450 mm) samples representative of the material being furnished. At the option of the Engineer, the manufacturer of the water seal may be required to submit a statement that the material furnished conforms to these requirements.

SECTION 1055. MASTIC JOINT SEALER FOR PIPE

1055.01 Requirements. Cold-applied bituminous sealer for culvert and sewer pipe joints shall be a bituminous material of such consistency that it can be applied to the joints with a trowel when the temperature of the air is between 20 and 100 °F (–7 and 38 °C). The bituminous material shall adhere to the concrete or clay pipe so as to make a watertight seal and shall not flow, crack, or become brittle when exposed to the atmosphere.

The mastic shall also be according to the following specific requirements.

Penetration 77 °F (25 °C), 150 g, 5 sec, with cone, 0.1 mm	175-300
Loss on Heating, 325 °F (163 °C), 5 hr, 50 g, percent	20 max
Inorganic content [complete burn, 1200 to 1400 °F (645 to 760 °C)], percent	15-40
Flow at 140 °F (60 °C), centimeters	0
Pliable at 0 °F (-17 °C)	Yes

The mastic shall be delivered to the project in suitable containers for handling and shall be sealed or otherwise protected from contamination. The container shall show the brand name, net volume or weight, and the requirements for application.

SECTION 1056. RUBBER GASKETS AND PREFORMED FLEXIBLE JOINT SEALANTS FOR CONCRETE PIPE

1056.01 Requirements. Rubber gaskets shall be according to AASHTO M 315 (M 315M). Preformed flexible joint sealants shall be according to AASHTO M 198.

SECTION 1057. EXTERNAL SEALING BAND

1057.01 Requirements. External sealing band, mastic, and film shall be according to ASTM C 877 (C 877M).

SECTION 1058. RESERVED

SECTION 1059. RESERVED

SECTION 1060. WATERPROOFING MATERIALS

1060.01 Description. Waterproofing materials shall include asphalt primer, waterproofing asphalt, waterproofing asphalt emulsion, and butyl rubber membrane. All waterproofing materials used in a given construction shall be uniform in character, appearance, and consistency.

1060.02 Sources of Supply. All sources of supply shall be approved by the Department.

1060.03 Measurement of Volume. Measurement of volume of asphalt primer, waterproofing asphalt, and waterproofing asphalt emulsion will be based on the volume of the material at 60 °F (15 °C). Volumes measured at higher or lower temperatures will be corrected to the volume of 60 °F (15 °C), using the Standard ASTM-IP Petroleum Measurement Tables, ASTM D 1250.

1060.04 Delivery. When waterproofing materials are not sampled at the source by a representative of the Department, they shall be delivered far enough in advance of their use on the work to permit the necessary tests to be made. Waterproofing materials shall be delivered in suitable containers or packages, plainly labeled to show the kind of material, the name of the manufacturer, and the lot or batch number. Each shipment shall be kept separate until the material has been accepted.

1060.05 Methods of Sampling. Samples of asphalt plank, asphalt panel, and butyl rubber shall be 3 ft (900 mm) in length and full width of the product.

1060.06 Asphalt Primer for Waterproofing. Asphalt primer for waterproofing shall be Rapid Curing Liquid Asphalt RC-70 as specified in Article 1032.07 and shall be used prior to the application of waterproofing asphalts: AWP-Type I and AWP-Type II.

1060.07 Asphalt for Waterproofing (AWP). Asphalt for waterproofing (AWP) shall be either Type I or Type II and shall be according to ASTM D 449.

- Type I. For use in waterproofing below ground level. The asphalt shall be free from water and shall not foam when heated to a temperature of 350 °F (177 °C).
- Type II. For use in waterproofing above ground level and for use in the construction of asphalt plank bridge floors. The asphalt shall be free of water and shall not foam when heated to a temperature of 400 °F (204 °C).

1060.08 Asphalt Emulsion for Waterproofing. Asphalt emulsion for waterproofing shall be an anionic type emulsion of asphalt in water with an asphalt content of 60 to 65 percent and a Saybolt Fural viscosity at 77 °F (25 °C) of 20 to 80 seconds when tested according to AASHTO T 59. The asphalt residue recovered from distillation according to AASHTO T 59 shall be according to the requirements of ASTM D 449, Type I, asphalts for waterproofing, with the exception; the ring and ball

softening point shall be excluded. In addition, the material shall meet the moisture retention requirements specified in Article 1022.01 and shall pass the following tests.

- (a) Resistance to Water Action. When tested according to ASTM D 466, no lifting of the film or darkening of the water will be permitted.
- (b) Freeze Recovery. Freeze recovery shall be tested in the following manner. Soak an unglazed ceramic tile, as used in ASTM D 466, in distilled water for ten minutes. Then place the tile in a freezer until the ice crystals form on the surface, at which time the tile is removed from the freezer and immediately coated with emulsion at room temperature as per ASTM D 466. The coated tile is then replaced in the freezer. After five hours, the tile is removed from the freezer and dried as per ASTM D 466. After drying, the tile is tested as per ASTM D 466. No lifting of the film or darkening of the water will be permitted.
- (c) Rain Resistance. Rain resistance shall be tested as follows. Dampen 3.5 oz (100 grams) of dry 1/4 to 3/8 in. (6 to 9 mm) stone chips with 0.04 oz (1 g) of water. Add 0.18 oz (5 g) of emulsion to the damp chips and mix for two minutes. When mixing is completed, place the coated chips on a screen and immerse them in a container of water at room temperature allowing them to soak one minute without movement. After soaking, remove from the water and examine for loss of coating. No loss of coating will be permitted.

1060.09 Butyl Rubber Membrane. Butyl rubber membrane shall be 1/8 in. (3 mm) thick. Rubber membrane shall be a compound butyl elastomer of the IIR Family (Isobutylene-Isoprene rubber) according to the following.

- (a) Butyl Membrane.

Color	Black
Specific gravity (ASTM D 297)	1.20 ± 0.03
Tensile strength (ASTM D 412)	1200 psi (8300 kPa) (min.)
Modulus at 300% elongation (ASTM D 412)	600 psi (4100 kPa) (min.)
Elongation (ASTM D 412)	300% (min.)
Tear resistance, die B (ASTM C 624)	150 psi (1034 kPa) (min.)
Hardness, Shore A (ASTM D 2240)	55 ± 5 with 5 sec interval before reading
Ozone resistance, 70 hr at 100 °F (38 °C) in 50 PPHM Ozone; 20% elongation	no cracks
Heat Aging, 7 days at 240 °F (116 °C)	70% of original properties
Maximum vol. Swell (Triscresyl Phosphate Immersion) 72 hr at 212 °F (100 °C)	10
Operating temperature range	-40 to 275 °F (-40 to 135 °C)
Water absorption, volume change	less than 1%

- (b) Adhesive. Adhesive for securing butyl rubber membrane and the protective cover shall be compatible to the membrane waterproofing and with the materials to which it is bonded. It shall remain workable to its brittle point [-40 °F (-40 °C)].

- (c) **Rubber Cement.** Rubber Cement for splicing rubber membrane shall be a self-vulcanizing butyl rubber compound according to the following.

Viscosity No. 3 Zahn Cup [77 °F (25 °C)]	100 to 150 sec.
Total Solids	30% (min.)

- (d) **Butyl Gum Tape.** Butyl gum tape for splicing butyl membrane shall be black, unvulcanized butyl rubber with an 8 mils (200 μ m) polyethylene film backing. The tape shall be 30 mils \pm 4 mils (0.8 mm \pm 100 μ m) thick, including the backing.

1060.10 Asphalt Plank. The asphalt plank shall be plain asphalt plank according to the requirements of ASTM D 517.

1060.11 Asphaltic Panel. The asphaltic panel shall be according to the requirements of AREMA Specifications, Chapter 29 for Membrane Waterproofing, Section/Article 2.4.7.

SECTION 1061. WATERPROOFING MEMBRANE SYSTEM

1061.01 Description. The waterproofing membrane system materials shall consist of a penetrating primer, coal tar pitch emulsion, fiber glass, slurry seal top coat, and a sand asphalt seal protection layer.

1061.02 Penetrating Primer. The primer shall be a highly penetrating solution that is compatible with the coal tar pitch emulsion and suitable for use on portland cement concrete surfaces. Asphaltic primers will not be permitted.

1061.03 Coal Tar Pitch Emulsion. The coal tar pitch emulsion shall be compounded of heavy closed ring hydrocarbons dispersed in water by means of a combination of irreversible colloidal clays.

- (a) **Sampling and Testing.** Prior to approval and use of the material for coal tar pitch emulsion and penetrating primer, the Contractor shall submit a certification by the manufacturer of each material, stating that it meets these requirements. This shall not constitute a waiver on the part of the Department of any requirements with respect to samples and samplings, and the right is retained to perform any or all of the tests specified.
- (b) **Ingredient Materials.** The coal tar pitch used in production of this material shall have a specific gravity at 77 °F/77 °F (25 °C/25 °C) of 1.20 to 1.27. By continuous hot extraction with benzol, after digesting in toluol, the insolubles ordinarily described as free carbon shall not be less than 12 percent. A cylinder of the pitch 1/2 in. (13 mm) in diameter and 6 in. (150 mm) long, which has been immersed in melting ice for at least 30 minutes, shall withstand being bent double without developing cracks at the point of greatest deflection; a duplicate cylinder, which has been immersed in melting ice for at least an hour, shall withstand twisting for two complete turns of 360 degrees each without showing cracks or fractures. The pitch

shall not be fluxed back with light oils, solvents, or any other adulterants before or during the emulsification process. Since these characteristics are not subject to test after emulsification, they are to be certified by the manufacturer.

The emulsion shall contain no sulphite pitches, asphalt, bentonite, coal dust, soluble soaps, or sulphonic acid and shall have sufficient thixotropic property so that at temperatures of 70 °F (21 °C) it may be temporarily reduced with agitation, to applied liquidity without addition of adulterants, to provide easy workability with brush or squeegee, and then reset in place.

(c) Properties.

- (1) Specific Gravity. A sample of the emulsion shall show a specific gravity at 77 °F/77 °F (25 °C/25 °C) of between 1.22 and 1.29.
- (2) pH. pH of the emulsion shall be 7.0 to 7.9 at 77 °F (25 °C).
- (3) Nonvolatile Matter. A sample of the emulsion when treated in an oven according to ASTM D 2939, shall show a minimum nonvolatile matter of 52 percent. This residue, when heated from room temperature to 518 °F (270 °C) in an oven within 30 minutes time, shall show a loss of not more than ten percent by weight (mass).
- (4) Ash Content. A sample of the residue from the determination of nonvolatile matter according to ASTM D 2939 shall show an ash content of 30 percent to 40 percent.
- (5) Resistance to Freezing.* A sample of the emulsion fortified with antifreeze shall be tested according to ASTM D 244. After exposure to a temperature of 0 °F (-18 °C) shall return to a homogeneous consistency with stirring.

*NOTE: The emulsion shall be fortified with antifreeze where climatic conditions surrounding the material in transit or storage are such to make resistance to freezing necessary.

- (6) Consistency. The emulsion when spread to a thin film with a spatula on a sheet of standard 18 lb (8.16 kg) paper shall flow with a uniformly smooth nongranular consistency, free from coarse particles which are either apparent or which cause film voids as the material is drawn out to a smear.
- (7) Flammability. The material shall be nonflammable when exposed to flame.
- (8) Drying Time. A test panel prepared according to ASTM D 2939, and exposed at a temperature of 77 °F (25 °C) and 50 percent relative humidity in activated air, shall set for touch within three hours and set within four hours.

(d) Cured Film Performance.

- (1) Resistance to Motor Oil, Gasoline, and Distilled Water. A 2 coat film of the emulsion with a minimum cured thickness of 1/16 in. (1.5 mm) shall be prepared on a 6 x 6 in. (150 x 150 mm) tile according to the Methods of Testing Films Deposited from Bituminous Emulsions, ASTM D 466. The cured film shall be tested according to ASTM D 466, using the above specified test liquids, except the test period shall be 48 hours. At the end of the test period, the test liquid shall be poured off and the film inside the ring impressions shall show no sign of film penetration nor loss of adhesion.
- (2) Heat Test. A 1/16 in. (1.5 mm) cured film of the emulsion shall be prepared and tested according to ASTM D 2939. At the end of the test period, none of the film shall have slipped below the reference line.
- (3) Flexibility. A 1/16 in. (1.5 mm) cured film of the emulsion shall be tested for flexibility according to ASTM D 2939. Immediately after bending, the film shall show no signs of cracking, flaking, or loss of adhesion.

1061.04 Fiber Glass Fabric. The fiber glass fabric shall be according to the requirements of the "Woven Glass Fabrics Treated for Use in Waterproofing and Roofing", ASTM D 1668, Type II or III, except that selvage edges will not be required, and the heat loss test shall not apply to coal tar pitch treated fabric.

1061.05 Aggregate for Slurry Seal Top Coat. The aggregate shall meet the requirements of Article 1003.01 be clean, dry, hard, and shall contain a minimum of dust. It shall be graded as follows.

Sieve Size	Passing Percent
No. 8 (2.36 mm)	100
No. 10 (2.00 mm)	90 - 100
No. 16 (1.18 mm)	10 - 75
No. 30 (600 µm)	0 - 10

1061.06 Protection Layer. The protection layer shall be a hot-mix-sand asphalt seal composed of the following materials.

- (a) Bituminous Material. The bituminous material shall be asphalt cement Grade PG58-22 or PG64-22 meeting the applicable requirements of Section 1032.
- (b) Fine Aggregate. The fine aggregate shall consist of sand, stone sand, or slag sand, Class B Quality or better, gradation FA 20, meeting the applicable requirements of Article 1003.01, except that no Type A or Type B sands will be allowed.

SECTION 1062. REFLECTIVE CRACK CONTROL SYSTEM

1062.01 Reflective Crack Control System A. The reinforcing fabric shall be a nonwoven polypropylene or other approved plastic fabric having the following properties.

Weight (ASTM D 3776) oz/sq yd (g/sq m), min.	4.0 (135)
Grab Tensile Strength (ASTM D 4632) lb (N), min.	90.0 (400)
Grab Elongation at Break (ASTM D 4632) %, min. - max.	40-100
Asphalt Retention gal/sq yd (L/sq m), min.	0.20 (0.9)

The asphalt binder shall be PG58-22 or PG64-22 meeting the requirements of Article 1032.05.

1062.02 Reflective Crack Control System B. Waterproofing membrane interlayer shall incorporate a high strength fabric embedded in a layer of self-adhesive suitably plasticized asphalt with the following properties.

Property	Value	Test Method
Thickness	0.065 in. (1.65 mm), min.	ASTM E 96
Permeance-Perms	0.10 (1.0) max.	Procedure B
Tensile Strength	50 lb/in. (8.7 N/mm), min.	ASTM D 882 (modified for 1 in. (25 mm) opening)
Puncture Resistance (fabric)	200 lb (90 kg), min.	ASTM E 154
Pliability -1/2 in. (-12.7 mm)-mandrel	No cracks in fabric or plasticized bitumen	ASTM D 146

1062.03 Reflective Crack Control System C.

- Asphalt. The grade of asphalt cement for the asphalt-rubber mixture shall be according to Article 1032.05 and shall be either PG 52-28, PG 58-28, or PG 58-22.
- Emulsified asphalt for tack coat shall be SS-1, SS-1h, SS-1hP, CSS-1, CSS-1h, or CSS-1hP, and shall be according to Article 1032.06.
- Vulcanized Rubber. The granulated crumb rubber shall be 100 percent vulcanized and meet the following gradation requirements.

Sieve Size	Percent Passing
No. 8 (2.36 mm)	100
No. 10 (2.00 mm)	98-100
No. 30 (600 µm)	0- 10
No. 40 (425 µm)	0- 4

The specific gravity of the material shall be 1.15 ± 0.02 and shall be free from fabric, wire, or other contaminated materials, except that up to four percent calcium carbonate may be included to prevent the rubber particles from sticking together.

Vulcanized rubber will be accepted by certification from the rubber supplier.

- (d) Diluent. The diluent shall be a solvent with an initial boiling point (IBP) of +350 when tested according to ASTM D 86.
- (e) Crumb Rubber Blend. The rubber shall be a blend of 40 percent powdered devulcanized rubber and 60 percent ground vulcanized rubber scrap specially selected to have a high natural rubber content. The blend shall meet the following specifications.

<u>Sieve Analysis</u> Sieve Size	<u>(ASTM D 1151)</u> % Passing
No. 10 (2.00 mm)	100
No. 30 (600 μ m)	60-80
No. 50 (300 μ m)	35-70
No. 100 (150 μ m)	10-25

The natural rubber content shall be a minimum of 30 percent by weight (mass), according to ASTM D 297 (D 297M). The devulcanized rubber content of the blend shall be 40 percent by weight (mass) and shall be determined by a mill test as follows.

When 1.4 – 1.8 oz (40 – 50 g) of rubber retained on the 30 mesh (600 μ m) sieve are added to the tight 6 in. (150 mm) rubber mill, the material should bond on the mill roll in one pass, and should usually be retained on the mill roll. This will indicate the presence of a suitable quantity of devulcanized rubber. The crumb rubber blend will be accepted by certification from the rubber supplier.

- (f) Extender Oil. Extender oil shall be compatible with all materials used and be a high flash, high viscosity resinous aromatic rubber extender oil.
- (g) Cover Aggregate. Aggregates for cover material shall be CA 14 or CA 15 according to Article 1004.03 for Class A use.

1062.04 Reflective Crack Control System D. The stress relief membrane shall be 36 in. (900 mm) wide and 0.15 in. (4 mm) thick and shall be a system of materials manufactured in a composite three layer fashion with the following properties.

Stress Relief Membrane		
Property	Value	Test Method
Cold Flex	No cracking or separation of fabric	ASTM D 146 (modified)
Tensile Strength (Peak)	4,000 psi (27,580 kPa) min.	ASTM D 412 (modified)
Elongation (at Peak Tensile)	10% min.	ASTM D 412 (modified)
Weight	0.76 lbs/sq ft (3.7 kg/sq m)	
Density (mastic)	69 lbs/cu ft (1100 kg/cu m) min.	ASTM D 70
Thickness	0.15 in. (4 mm)	ASTM D 1777
Resistance to Puncture	5,000 psi (34,400 kPa)	ASTM D 3786
Absorption (mastic)	1 % max.	ASTM D 517
Brittleness	Passes	ASTM D 517
Softening Point (mastic)	220 °F (104 °C)	ASTM D 36

The bottom layer of the composite shall be a low strength, nonwoven, geotextile and shall be according to AASHTO M 288. The bottom geotextile shall be designed to fully bond with the existing pavement with the help of a tack coat. It shall be capable of accommodating sufficiently large stresses at the joint/crack without breaking its bond with the slab. The middle layer of the composite shall be a viscoelastic membrane designed to prevent water entry into the pavement through the cracks and/or joints in the pavement. It also acts as a stress absorbing member interlayer between the overlay and the underlying pavement. The top layer shall be a high strength woven geotextile with a tensile strength of 4,000 psi (27,580 kPa) at five percent strain according to ASTM D 4595. The top geotextile shall be designed to fully bond with the overlay and provide high stiffness and reinforcement to the overlay.

The stress relief membrane shall be stored in an inside enclosure with temperatures not exceeding 120 °F (49 °C). Any material that becomes wet prior to installation shall be removed from the jobsite and discarded.

The manufacturer shall furnish a certification with each shipment of stress relief membrane, stating the amount of product furnished, and that the material complies with these requirements.

SECTION 1063. FIBERGLASS FABRIC REPAIR SYSTEM

1063.01 Requirements. The fiberglass fabric repair system shall consist of two components, fiberglass and bituminous adhesive.

The fiberglass fabric shall consist of a heavyweight high strength woven fiberglass roving according to the following physical properties.

Strip tensile strength, ASTM D 579 Modified 1 in. (25 mm) cut strip test, Procedure 2 Strain rate of 0.5 in./min (15 mm/min) in a CRE testing machine, 3 in. (75 mm) gage length, test both warp and fill directions	800 lb/in. (140 N/mm), min.
Weight (Mass)22 oz/sq yd (745 g/sq m), min.

The bituminous adhesive shall consist of an asphaltic polymer that has high adhesion and low tack and is compatible with the fiberglass fabric, and shall be according to the following physical properties.

Penetration, ASTM D 5 @ 77 °F (25 °C), 100g, 5 sec	30-60
Softening Point, ASTM D 36	180 to 240 °F (82 to 116 °C)
Viscosity, ASTM D 3236 @ 380 °F (193 °C)	
Centipoise (Pa·s)	800-2000 (0.8-2)

Thermal Stability, ASTM D 5329 Prolonged
Heating Method, 6 hrs @ 400 °F (205 °C) and the
retested sample shall be according to the
requirements above and the following.

Low Temperature Flexibility, ASTM C 711 Mod	-10 °F (-23 °C) max.
[1 in. (25 mm) diameter mandrel]	

The fiberglass fabric repair system shall consist of the fabric coated on both sides with bituminous adhesive and shall be according to the following physical properties.

Strip tensile strength, ASTM D 579 Modified	1000 lb/in. (175 N/mm) min.
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1 in. (25 mm) cut strip test, Procedure 2
Strain rate of 0.5 in./min (13 mm/min) in a CRE Testing machine,
3 in. (75 mm) gage length, test both warp and fill directions.

LIGHTING**SECTION 1064. RESERVED****SECTION 1065. PROTECTIVE DEVICES**

1065.01 Fuseholders and Fuses. Fuseholders and fuses shall be as follows.

(a) Fuseholders.

- (1) General. Each fuseholder shall consist of a two-section unit designed to hold small-dimension cylindrical fuses of the type required. Each section shall be permanently marked with line and load side designations and the unit shall have a water and vapor-tight seal when the sections are joined. Two pole quick disconnect fuseholders shall be used unless otherwise specified.

The terminals and the contacts in the fuseholder shall be made of tinned copper or other material suitable for contacts as approved by the Engineer. The contacts shall be spring loaded or tulip style to exert contact pressure on mating parts. Fuse holders shall be rated for 30 A at 600 V at 167 °F (75 °C) operation.

- (2) Fuseholder Material. Fuseholders shall have a molded plastic, neoprene rubber, or impact resistant polymer housing. Wires shall attach to the fuse holder by a crimping operation, except that connection of No. 2 wires to breakaway fuse holder receptacles may be via a set screw connection. Each fuse holder shall be of a size proper for the wires to be attached. The assembly shall be provided with insulating boots as needed.

- (3) Fuseholder Design. Phase to phase circuit applications shall be designed so that both phase conductors are disconnected at the same time. Phase to neutral circuit applications shall be designed so that both phase and neutral conductors are disconnected at the same time. Blanks shall be used instead of fuses for the neutral conductor and they shall be clearly marked with white bands to designate a neutral plug.

- (4) Fuseholder Operation. The fuseholder shall be capable of disconnecting upon sufficient tension in the connected wires, as in a pole knockdown. The fuse shall remain enclosed in the de-energized portion of the fuseholder upon disconnection. The fuse shall not be utilized as the disconnection means.

- (b) Fuses. Fuses for installation within fuse holders for protection of luminaires shall be small-dimension, 1 1/2 in. x 13/32 in. (38 mm x 10 mm), cylindrical fuses of the time-delay type. The fuses shall be rated for 500 V AC and meet the requirements of UL Standard 248-14. The fuses shall have a UL listed interrupting rating of not less than 10,000 rms symmetrical amperes at

rated voltage. They shall be sized at 300 percent of the starting or operating current whichever is greater, but in no case greater than 50 percent of the branch circuit conductor ampacity.

1065.02 Lightning Protection. The surge protector shall be totally weatherproof, and shall withstand a surge current up to 20,000 amperes (8 X 20 micro seconds) and repetitive surges of 200 amperes for a minimum of 10,000 occurrences. Response time shall be less than 50 nanoseconds. The current drain shall not exceed 100 microamperes. The unit shall not allow holdover current or conduction to ground after the surge ends.

Protection shall be achieved for both phase and neutral conductors with surges being passed to ground and not to neutral. There shall be no discharge lag in the protection of phase conductors over the neutral conductor.

SECTION 1066. WIRE AND CABLE

1066.01 Unit Duct. The unit duct shall be an assembly of insulated conductors which are factory pre-installed in a coilaible nonmetallic conduit. The polyethylene duct shall be extruded directly over the cable at the factory in long continuous lengths. The unit duct shall be according to UL Standards 651B and 1990.

1066.02 Conductors. All cable shall be rated 600 V. The cable shall be rated 90 °C wet and dry and shall be resistant to oils and chemicals. Any cable used for a service entrance shall have a Type USE-2 rating.

The UL listing mark, cable voltage, insulation type and ratings, as well as the cable size shall all be clearly printed on the cable in a color contrasting with the insulation color. When specified, each cable installed shall be identified with its complete circuit number at each termination, splice, junction box or other location where the wire is accessible.

All electric cables installed shall be color coded. Neutral wires shall be color coded white. Single phase three wire runs of cable shall be color code one black, one red, and one white; three phase three wire runs of cable shall be color coded one black, one red, and one blue. Single phase two wire runs shall be similarly color coded based on the applicable phase(s) and neutral. The insulated ground wires and the equipment grounding conductor shall be green. Tape on the conductor or color striping of cables will not be acceptable in lieu of the specified color coding means.

Cables sized larger than No. 2 AWG shall be color coded as specified having not less than 12 in. (300 mm) of cable ends field-taped with half-lapped color tape or by other means approved by the Engineer.

(a) Copper Conductors. Conductors shall be uncoated or coated copper.

Uncoated conductors shall be according to ASTM B 3, ICEA S-95-658, NEMA No. WC-70, and UL Standard 44. Coated conductors shall be according to ASTM B 33, ASTM B 8, ICEA S-95-658, NEMA No. WC-70 and UL Standard 44.

All conductors shall be stranded. Stranding shall meet ASTM B 8 (or ASTM B 496 for conductors larger than No. 2 AWG), ICEA S-95-658, NEMA No. WC-70 and UL Standard 44.

- (b) Aluminum Conductors. Conductors shall be aluminum according to ASTM B 230 and shall be Class B stranded according to ASTM B 231, and shall be according to the values listed in the table in Article 1066.03.

1066.03 Cable Insulation. Insulated cable designated as XLP shall incorporate cross-linked polyethylene (XLP) insulation and shall meet or exceed the requirements of ICEA S-95-658, NEMA Standard Publication No. WC-70, and UL Standard 44. Minimum insulation thickness at any point shall not be less than 90 percent of the average insulation's thickness listed in the following tables.

- (a) Non-Aerial Cable Insulation. Cables sized No. 2 AWG and smaller shall be solid color coded with XLP insulation of minimum average thickness as indicated in the following table.

Insulation Thickness for Cables No. 2 AWG and Smaller	
Conductor Size, AWG	Average Insulation Thickness
No. 10 and Smaller	45 mils (1.1 mm)
No. 8 through No. 2	60 mils (1.5 mm)

Cables larger than No. 2 shall be insulated by XLP insulation over the conductor with minimum average thicknesses not less than indicated in the following table.

Insulation Thickness for Cables Larger than No. 2 AWG	
Conductor Size, AWG	Average Insulation Thickness
No. 1 through No. 4/0	80 mils (2 mm)
250 MCM through 500 MCM	95 mils (2.4 mm)

- (b) Aerial Cable Insulation. The conductors shall have the minimum average insulation thickness indicated in the following table.

Aerial Electric Cable Properties					
Phase Conductor			Messenger wire		
Size AWG	Stranding	Average Insulation Thickness		Minimum Size AWG	Stranding
		mils	mm		
6	7	45	(1.1)	6	6/1
4	7	45	(1.1)	4	6/1
2	7	60	(1.5)	2	6/1
1/0	19	60	(1.5)	1/0	6/1
2/0	19	60	(1.5)	2/0	6/1
3/0	19	60	(1.5)	3/0	6/1
4/0	19	60	(1.5)	4/0	6/1

1066.04 Aerial Cable Assembly. The aerial cable shall be an assembly of insulated aluminum conductors according to Articles 1066.02 and 1066.03 and a steel messenger wire according to ANSI/ICEA S-76-474. The cable assembly may have the messenger wire intertwined with the insulated cables or lashed to the insulated cables by a factory wrap.

The cable shall be assembled according to ANSI/ICEA S-76-474.

1066.05 Underground Cable Marking Tape. The tape shall be 6 in. (150 mm) wide; consisting of 7 mil (0.18 mm) minimum polyethylene according to ASTM D 882, ASTM D 5034, ASTM D 5035 and ASTM D 2103. The tape shall be red with black lettering or red with silver lettering reading "CAUTION – ELECTRICAL LINE BURIED BELOW".

When specified, the tape shall be a woven reinforced polyethylene tape with a metallic core or backing that is detectable.

1066.06 Splicing and Termination of Electric Cable.

- (a) General. Splices in electrical cables shall be made with materials which are compatible with conductors, insulations, and any jackets of the associated cables. The connectors shall be listed for the quantity and size of conductors to be spliced.
- (b) Capped Splice. When specified, splices above grade, such as in poles and junction boxes, shall have a waterproof sealant and a heat shrinkable plastic cap. The cap shall be of a size suitable for the splice and shall have a factory applied sealant within. Additional seal of the splice shall be assured by the application of sealant tape or the use of a sealant insert prior to the installation of the cap. Either method shall be compatible with the cap sealant. Tape sealant shall be applied in not less than one, half-lapped layer for a length at least 1/4 in. (6.35 mm) longer than the cap length and the tape shall also be wrapped into the crotch of the splice. Insert sealant shall be placed between the wires of the splice and shall be positioned to line up flush or extend slightly past the open base of the cap.

The end caps shall have a post shrink wall thickness not less than the following.

Initial Inside Diameter		Post-Shrink Wall Thickness	
in.	(mm)	in.	(mm)
0.50	13	0.070	1.78
0.75	19	0.080	2.03
1.00	25	0.095	2.41
1.15	29	0.095	2.41
1.50	38	0.100	2.54
2.00	50	0.105	2.67

- (c) Taped Splice. Remove 6 in. (150 mm) of insulation for compression splices or 3 in. (75 mm) of insulation for pressure connectors from the end of the

cable and thoroughly clean the conductor for splicing. Apply the connector according to manufacturer's recommendations. Apply three layers of half-lapped rubber tape or one layer of 1/8 in. (3 mm) thick electrical insulation putty. The tape or putty shall completely enclose the bare splice and a minimum of 2 in. (50 mm) of insulation on each cable. Work the tape or putty with finger pressure to fill irregularities and form a smooth mold. Next apply two half-lapped layers of plastic electrical tape covering all rubber or putty filled areas and extending a minimum of 1 in. (25 mm) over the insulation of each cable. Brush on and completely cover the splice with a clear sealant and bonding compound that is specifically formulated for plastic electrical tape. Orient the finished splice so that the cables enter the splice from below.

- (1) **Pressure Connectors.** When specified, waterproof pressure type connectors may be used for #6 or smaller copper conductors in conductor combinations recommended by the manufacturer. High quality factory applied contact paste and sealant shall be supplied inside the connectors. Pressure connectors shall be covered with a tape sealant as noted above or with an Engineer approved sealant system after they are installed.
- (2) **Compression Connectors.** Individual conductors, including ground conductors, shall be terminated with compression terminals sized appropriately for the given connection. The connectors shall be copper and comply with UL Standard 486A. The terminals shall be clearly marked with the wire size and die index. All compression terminals shall be installed with the proper tool and die for crimping. Grounding conductors shall be connected to poles, sign structures, and the like using materials specifically listed for the applicable grounding. Connections at metal boxes or enclosures shall be made by means of a suitable grounding screw used for no other purpose or by a listed grounding device. Splices for multiple conductors shall be copper compression joint sleeves. Copper compression joints (sleeves) shall be made of tin plated copper and be UL listed for 600 volt applications and shall be of the type suitable for a range of conductor combinations. Compression connectors shall be covered with a tape sealant as noted above or with an Engineer approved sealant system after they are installed.

1066.07 Wiring Identification Markers. Wiring identification markers shall be as follows.

- (a) **Cloth Tape Wire Markers.** Wire identification shall be made by the application of self-sticking wire markers, wrapped around the wire. The markers shall have black characters not less than 5/16 in. (8 mm) high on a white or yellow background. Markers shall be in strips not less than 1 1/2 in. (38 mm) long and shall be made of a high-tack cloth tape with printing protected by a clear, permanent overcoating.
- (b) **Clip-On Wire Markers.** Clip-on wire markers shall be white with black lettering. The proper size of wire markers shall be used to prevent slipping of the markers on the cable.

1066.08 Electrical Tape. Electrical tape shall be all weather vinyl plastic tape resistant to abrasion, puncture, flame, oil, acids, alkalies, and weathering, according to UL Standard 510 and ASTM D 1000. Thickness shall not be less than 8.5 mils (0.215 mm) and width shall not be less than 3/4 in. (20 mm).

1066.09 Wire in the Pole. Pole wire shall run from handhole to luminaire. Pole wire shall be sized No. 10, rated 600 V, RHW/USE-2, and have copper conductors, stranded in conformance with ASTM B 8. Pole wire shall be insulated with cross-linked polyethylene (XLP) insulation.

Color coding of the pole wire shall be via solid insulation color. Neutral wires shall be white and phase conductors shall be color coded red or black as appropriate to match the associated branch circuit conductors. Cable identification marking shall be visible in a contrasting color.

SECTION 1067. LUMINAIRE

1067.01 General. The luminaire shall be optically sealed, mechanically strong and easy to maintain. The luminaire shall be designed as to its size, shape and weight so it does not aggravate the vibration characteristics of its respective pole and it shall be compatible with the pole and arm.

- (a) **Lamp Socket.** The lamp socket shall be mogul type, glazed porcelain, one piece rolled threads with stationary socket lead connectors that will not move during lamp insertion and removal. The rating of the socket shall exceed the lamp starting voltage, or starting pulse voltage rating.
- (b) **ANSI Identification Decal.** A decal, complying to ANSI C 136.15, shall be factory attached permanently to the luminaire. The information contained in the decal shall enable a viewer, from the ground level, to identify the lamp wattage and type of luminaire distribution.
- (c) **Optical Assembly.** The reflector shall be made of 0.02 in. (0.5 mm) minimum thickness specular aluminum sheet. The surface shall have a dense protective coating of oxide not less than 7.5 mg/sq in. (0.012 mg/sq mm), applied by an anodic oxidation process. A glass reflector finish may be substituted in place of an oxide coating. The glass finish shall be chemically bonded to the reflector and shall be flexible, impact resistant, and heat resistant.

Segmented reflectors, if used, shall have extensive bracing and support of the reflective segment members to minimize the potential for accidental bending of the segments during installation or maintenance. The reflector, the refractor or lens, and the entire optical assembly shall not develop any discoloration over the normal life span of the luminaire.

Luminaire efficiency, defined by the I.E.S. as "the ratio or luminous flux (lumens) emitted by a luminaire to that emitted by the lamp or lamps used within", shall not be less than 67 percent. Submittal information shall include published efficiency data.

- (d) Lens and Frame. Luminaires shall have lenses made of crystal clear, impact and heat resistant flat glass. Where refractors are specifically indicated or permitted, they shall be prismatic, impact and heat resistant glass meeting the mechanical interchangeability requirements of ANSI C136.17. All glass lenses shall meet the requirements of ANSI C136.28.

The lens shall be held within a metal frame of the same material as the housing. The lens shall be held in such a manner as to allow for its expansion and contraction. The lens frame assembly shall hinge down for access to the internal components of the luminaire. The hinge arrangement may be heavy-duty pin-type hinges or other arrangements approved by the Engineer, but the assembly shall assure that the lens frame will open for clear access to the inside of the luminaire and that easy positive alignment of the frame upon re-closing, without lifting and/or shifting of the frame, is assured. The lens frame shall be gasketed and held securely closed by stainless steel spring-loaded toggle-action latches, easily operated without the use of tools.

- (e) Housing. The luminaire shall be gasketed and sealed, U.L. listed for wet locations and shall have a minimum IEC ingress penetration rating of IP55. Unless otherwise specified, the housing shall be die cast aluminum, continuous without seams or welds and shall be free of burrs and protrusions. The cover with refractor or lens shall be securely attached to the main housing and be readily removable for luminaire servicing.
- (f) Ballast. The ballast shall be integral to the luminaire. Integral ballast components shall be mounted in the rear of the luminaire on the inside of a removable door or on a removable mounting pad. Ballast wiring and lamp socket wiring shall be connected by means of a plug according to ANSI C136.33. Upon unplugging the ballast wiring the entire ballast assembly shall remove for maintenance. The removable door or pad shall be secure when fastened in place and all individual components shall be secure upon the removable element. Each component shall be readily removable from the ballast tray for replacement.

Ballasts shall maintain a power factor of 0.9 or higher under all assigned loading conditions.

Ballasts shall not be noisy. Noticeable noisy ballasts, as determined by the Engineer, will not be accepted.

The ballast shall provide lamp operation within lamp specifications for the rated lamp life at its input design voltage range. It shall have a six month operation capability with a cycling lamp.

Submittal information shall include manufacturer's literature and date to confirm compliance with all specified requirements including an ANSI Standard Ballast Characteristic Graph (Trapezoid) diagram, with all items clearly identified.

The lampholder and ballast components shall be completely wired, with connections made to a heavy duty terminal board with plug-in (pressure) connectors. Leads shall not be smaller than #16 AWG conductors. These shall be coded by tagging and/or color coding for proper identification. A complete legible wiring diagram coordinated with the wire identifications shall be displayed at a convenient location on the interior of the luminaire according to ANSI C136.22.

Specific requirements for each kind of ballast are as follows.

- (1) High Pressure Sodium Reactor. The ballast shall be a high power factor magnet regulator (lag type) as specified herein.

The ballast shall produce positive lamp ignition over a voltage range not less than ± 10 percent of nominal system voltage. Operating characteristics shall produce output regulation not exceeding 20 percent. For this measure, regulation shall be defined as the ratio of the lamp watt difference between the upper and lower operating curves to the nominal lamp watts; with the lamp watt difference taken within the ANSI trapezoid parallel to the minimum lamp volt line.

The ballast shall be designed to furnish proper electrical characteristics for starting and operating a high pressure sodium vapor lamp of the specified rating at ambient temperatures of -20 to 104°F (-29 to 40°C). The ballast windings shall be adequately impregnated and treated for protection against the entrance of moisture, insulated with Class H insulation, and able to withstand the NEMA standard dielectric test.

Ballast losses, based on cold bench tests, shall not exceed 20 percent to a nominal 100 V, 400 W lamp and 25 percent for other sizes. The ballast shall include an electronic starting assembly. The starter assembly shall be comprised of solid state devices capable of withstanding ambient temperatures of 185°F (85°C).

- (2) Fluorescent, High Output. The electronic ballast shall be mounted within the fixture and be designed to operate at 240 VAC, 60 Hz, with a high power factor. The ballast shall be capable of starting and operating two F72T8/HO rapid start, high output, cool white fluorescent lamps at a minimum temperature of -20°F (-29°C).
- (g) Photometric Performance. The luminaire photometric performance shall produce results equal to or better than those listed in the applicable Luminaire Performance Table or tables. Submittal information shall include computer calculations based on the given controlling conditions which demonstrate achievement of all listed performance requirements. The computer calculations shall be done according to I.E.S. recommendations and the submitted calculations shall include point-by-point illuminance, luminance and veiling luminance as well as listings of all indicated averages and ratios as applicable. The program used to perform the calculations shall be identified on the submittal.

In addition to computer printouts of photometric performance, submittal information shall include the following.

- (1) Descriptive literature
 - (2) Isofootcandle chart of horizontal lux (footcandles)
 - (3) Utilization curve
 - (4) Isocandela diagram
 - (5) Luminaire classification per ANSI designation
 - (6) Candlepower values at every 2.5 degree intervals
 - (7) Candlepower curves shall be provided in the I.E.S. format.
- (h) Independent Testing. When a contract has 30 or more luminaires of the same type, that luminaire type shall be independently tested. For each luminaire type requiring independent testing, one luminaire plus one additional luminaire for each additional 50 luminaires shall be tested. The Contractor shall coordinate the independent testing and propose a qualified independent agent, familiar with the luminaire requirements and test procedures, for approval by the Engineer, to witness the required tests as performed by the luminaire manufacturer.

The independent witness shall select from the project luminaires at the manufacturer's facility or at the Contractor's storage facility, the luminaires for testing. In all cases, the selection of luminaires shall be a random selection from the entire completed lot of luminaires required for the contract. Selections from partial lots will not be allowed.

The selection of the proposed independent witness (independent laboratory as required) shall be presented with the information submitted for approval.

The testing performed shall include photometric and electrical testing. Photometric testing shall be according to IES recommendations and as a minimum, shall yield an isofootcandle chart, with max candela point and half candela trace indicated, an isocandela diagram, maximum planned and maximum cone plots of candela, a candlepower table (House and street side), a coefficient of utilization chart, a luminous flux distribution table, BUG rating report, and complete calculations based on specified requirements and test results.

Electrical testing shall conform to NEMA and ANSI standards and, as a minimum, shall yield a complete check of wiring connections; a ballast dielectric test; a ballast transient voltage test; total ballast losses in watts and percent of input; a lamp volt-watt trace; regulation data; a starter test; lamp current crest factor; power factor (minimum over the design range of input voltage at nominal lamp voltage); and a table of ballast characteristics showing input amperes, watts and power factor, output volts, amperes, watts

and lamp crest factor, as well as ballast losses over the range of values required to produce the lamp volt-watt trace.

The summary report and the test results shall be certified by the independent test laboratory or the independent witness, as applicable, and shall be sent by certified mail directly to the Engineer. A copy of this material shall be sent to the Contractor at the same time.

Should any of the tested luminaires of a given distribution type and wattage fail to satisfy the specifications and perform according to approved submittal information, the luminaire of that distribution type and wattage shall be unacceptable and be replaced by alternate equipment meeting the specifications with the submittal and testing process repeated in their entirety; or corrections made to achieve required performance. In the case of corrections, the Contractor shall advise the Engineer of corrections made and shall request a repeat of the specified testing and, if the corrections are deemed reasonable by the Engineer, the testing process shall be repeated. The number of luminaires to be tested shall be the same quantity as originally tested.

Submittal information shall include a statement of intent to provide the testing as well as a request for approval of the chosen laboratory.

- (i) Finish. Luminaires shall have a baked acrylic enamel finish. For weathering steel poles, the color shall be bronze. For an aluminum or galvanized steel pole, the color shall be munsell grey. The luminaire shall match other pole types and finishes as approved by the Engineer.
- (j) Hardware. All hardware shall be stainless steel or of other high-strength corrosion resistant material approved by the Engineer and shall be of extra heavy duty construction.

Fasteners such as quarter-turn clips shall be heavy spring loaded type with large, deep straight slot heads, complete with receptacle and shall be according to Military Specification MIL-F-5591.

All hardware shall be captive, not susceptible to falling from the luminaire during maintenance operations. This shall include lens/lens frame fasteners as well as hardware holding the removable ballast/electronic components in place.

- (k) Vibration Characteristics. All luminaires shall be vibration tested and pass ANSI C136.31 requirements. Roadway luminaires mounted on a bridge and high mast luminaires shall be rated for "3G" minimum peak acceleration. The "3G" rated luminaire shall be provided with a grip or suitable device to hold the lamp against vibration. In order to be accepted, the luminaire housing, hardware, and each individual component shall pass this test with no noticeable damage and the unit must remain fully operational after testing.

1067.02 Roadway Luminaire. Roadway luminaries shall be according to Article 1067.01 and the following.

- (a) Horizontal Mount. The effective projected area of the luminaire shall not exceed 1.6 sq ft (0.149 sq m). The luminaire shall meet the requirements of ANSI C136.14.

The luminaire shall slip-fit on a 2 to 2 3/8 in. (50 to 60 mm) O.D. pipe arm and shall have a barrier to limit the amount of insertion. It shall not be necessary to remove more than the cover, reflector, and refractor or lens to mount the luminaire.

The luminaire shall be provided with a leveling surface and shall have a four bolt anchoring/attachment means so as to be capable of being tilted by ± 3 degrees and rotated to any degree with respect to the supporting arm.

The luminaire shall have a built in device indicating the direction and amount of tilt over a range of zero to five degrees and shall be accurate to within 1/2 degree. The indication shall be clearly visible in daylight to an observer located a minimum of 50 ft (16 m) below the luminaire.

The luminaire shall have a full cutoff classification as defined in the "American National Standard Practice for Roadway Lighting", ANSI-IES (RP-8) and shall produce a medium vertical distribution and a Type III lateral distribution.

- (b) Multi-Mount. The luminaire shall be a pole top, vertical slip fitter, single lamp fixture. The effective projected area of the luminaire shall not exceed 2.9 sq ft (0.27 sq m). The luminaire shall meet the requirements of ANSI C136.32.

The luminaire shall be equipped with a vertical slip-fitter and a leveling aiming adjustment assembly for rapid and versatile field installation. The slip-fitter shall accept 2 3/8 to 3 in. (60 to 75 mm) O.D. tenons. The assembly shall provide an adjustment of ± 15 degrees about a standard luminaire orientation of 45 degrees.

- (c) Rectilinear. The luminaire shall meet the requirements of ANSI C136.23.

In addition to Article 1067.01(e), the luminaire housing may be made of extruded aluminum. Any welds made to the extruded housing shall be continuous. Seams shall be ground smooth without the use of fillers.

1067.03 High Mast Luminaire. High mast luminaries shall be according to Article 1067.01 and the following.

The luminaire shall be designed and manufactured for high mast tower use. It shall be designed to withstand constant 80 mph (130 km/hr) wind speeds and 104 mph (167 km/hr) gusts and the physical stresses associated with such duty including shocks and vibrations.

- (a) Horizontal Mount. The luminaire shall meet the requirements of ANSI C136.18.

- (1) Lens and Lens Frame. The lens shall be flat or convex, but convex lenses shall not be more than 3 3/4 in. (95 mm) convex from flat. The luminaire shall meet the IES luminaire classification for full cutoff or cutoff, as specified.
- (2) Reflector. The reflector and lamp socket assembly shall be capable of being rotated 360 degrees around its vertical axis. The luminaire shall be equipped with identifying markings to indicate the mounted orientation. Luminaire installation shall include engraved banding of the mounting arms to designate proper orientation.

The luminaire shall be designed such that when the reflector must be hinged open or otherwise moved to relamp the luminaire, the reflector shall remain captive to the luminaire and shall not interfere with the access required.

The design of the optical assembly shall permit the removal of the reflector without requiring the direct handling of the reflective portion of the assembly.

- (3) Open Bottom Style Luminaire. For an open bottom luminaire, the reflector shall be constructed of pressed, prismatic, annealed, borosilicate glass. The luminaire shall operate as an open-ventilated unit permitting free flow of air upward by chimney action through the optical assembly.
- (b) Multi-Mount Type. Multi-mount high mast luminaires shall be according to Article 1067.02(b).

1067.04 Underpass Luminaire. Underpass luminaires shall be according to Article 1067.01 and the following.

The underpass luminaire shall be complete with all supports, hardware, and appurtenant mounting accessories. The underpass luminaire shall be suitable for lighting a roadway underpass at approximate mounting height of 15 ft (4.5 m) from a position suspended directly above the roadway edge of pavement or attached to a wall or pier. The underpass luminaire shall meet the requirements of ANSI C136.27.

It shall not be necessary to remove more than the cover, reflector and lens to mount the luminaire. The unit shall be heavy duty, suitable for highway use and shall have no indentations or crevices in which dirt, salt, or other corrosives may collect.

The light source shall be High Pressure Sodium.

- (a) Housing. The housings and lens frame shall be made of 16 gauge (1.5 mm) minimum thickness stainless steel according to ASTM A 269, Grade 304L. All seams in the housing enclosure shall be welded by continuous welds.

The housing shall have an opening for installation of a 1 in. (25 mm) diameter flexible conduit.

When specified, housings shall be made of heavy duty die cast aluminum.

- (b) Lens and Lens Frame. The frame shall not overlap the housing when closed. When in the open position, the frame shall unhinge and be removable for maintenance and shall be held captive by a chain or other means approved by the Engineer. The lens frame shall be hinged with a continuous stainless steel piano type hinge.
- (c) Mounting Bracket. Four luminaire mounting brackets fabricated from 11 gauge (3.05 mm) stainless steel according to ASTM A 269, Grade 304L shall be welded to the luminaire housing.

1067.05 Sign Luminaire. Sign luminaries shall be according to Article 1067.01 and the following.

The luminaire shall be suitable for lighting expressway guide signs.

(a) Fluorescent.

- (1) Housing. The outer housing shall be constructed from 0.064 in. (1.6 mm) thick ASTM B 209, Alloy 3003-H14 aluminum. The housing shall have an extruded aluminum hinge, one half of which is an integral part of the housing.
- (2) Lens and Frame. The lens frame shall be made of extruded aluminum and have a continuous extruded neoprene gasket seal to insure weatherproofing. The frame shall have a concealed retaining latch which locks the door open for servicing and shall include a safety chain. The lens shall be made of clear 0.125 in. (3 mm) thick acrylic.
- (3) Lamp Holders. The lamp holders shall be end mounted, spring loaded, self-sealing, and self-aligning.
- (4) Wiring. All wiring connections in the fixture shall terminate on molded phenolic, barrier type, heavy duty, terminal blocks rated for a maximum current of 30 amperes and rated voltage of 600 V. The terminal block shall accommodate No. 10 AWG wire and shall be color marked to suit the ballast wire colors. All wiring, terminal blocks, and ballast shall be fully enclosed within the fixture so none of the above parts are exposed when relamping.

(b) High Pressure Sodium.

- (1) Housing. The housing shall support and enclose the reflector, electrical assembly, and 1 1/4 in. (30 mm) conduit supports and shall interact with the hingeable door to provide a watertight lamp environment. A single piece weather resistant gasket shall seal the door to the housing when stainless steel door latch bolts are secured. The integrally cast hinge shall allow the door to stand open to allow full access to the electrical components. Housing shall be provided with pads for three point surface mounting.

- (2) Lens and Frame. The lens frame shall have self-supporting hinges and an integral glare shield.
- (3) Wiring. Ballast components shall be heat sunk against the cast aluminum housing.
- (4) Performance. The optical assembly shall provide an illumination level on the sign face that does not exceed a gradient ratio of 2.0.

1067.06 Lamps. The lamps in all luminaires shall be according to ANSI requirements.

(a) High Pressure Sodium Vapor Lamps.

- (1) The lamps shall be of the clear type and shall have a color of 1900 to 2100 Kelvin.
- (2) At half of the average rated lamp life, the mean output lumens shall not be less than 90 percent of initial lumen output.
- (3) High pressure sodium lamps shall be non-cycling type and suitable for any burning position.
- (4) High pressure sodium lamps shall meet or exceed the following characteristics.

Lamp Wattage (Watts)	Rated Life (Hours)	Initial Lumen Output (Lumens)	Lamp Voltage (Volts)
35	16,000	2,250	52
50	30,000	4,000	52
70	30,000	6,300	52
100	30,000	9,800	55
150	30,000	16,000	55
200	30,000	22,000	100
250	30,000	28,500	100
310	30,000	37,000	100
400	30,000	50,000	100
750	30,000	105,000	120
1000	30,000	130,000	250

(b) Pulse Start Metal Halide Lamps.

- (1) The lamps shall be of the clear type and shall have a color of 3000 to 4400 Kelvin.
- (2) At 40 percent of the average rated lamp life, the mean lumens shall not be less than 60 percent of initial lumen output.
- (3) Lamps shall be suitable for the burning position orientation of the luminaires for which they are supplied.

- (4) Pulse start metal halide lamps shall meet or exceed the following characteristics.

Lamp Wattage (Watts)	Rated Life (Hours)	Initial Lumen Output (Lumens)
70	7,500	5,500
100	15,000	8,500
150	15,000	12,900
175 Vertical	15,000	16,000
175 Horizontal	11,500	12,800
250 Vertical	15,000	23,000
250 Horizontal	12,000	19,000
400 Vertical	20,000	40,000
400 Horizontal	15,000	31,000
750 Vertical	16,000	78,000
750 Horizontal	12,000	68,000
1,000 Vertical	12,000	110,000
1,000 Horizontal	9,000	105,000

- (c) Fluorescent. Fluorescent lamps for sign lighting shall rapid start, high output, cool white, Type F72T8/CW/HO with an average rated life of 18,000 hours and a mean lumen output of 5,490 lumens. The lamp shall have a color temperature of 4100 K and a CRI of 85. All fluorescent lamps shall be capable of starting and operating at a minimum temperature of -20 °F (-29 °C).
- (d) Incandescent. Incandescent lamps shall be a type having a minimum average rated life of 2,500 hours. A 100 watt lamp shall produce a minimum of 1,190 lumens. Other lamps shall be of the extended service type of the wattage indicated.

1067.07 Navigation Obstruction Warning Luminaires.

- (a) Waterway Obstruction Warning Luminaire. The fresnel lens shall be one piece, precision molded, color impregnated tempered glass. Astragals shall be oriented so as to minimize their impact on the light beam at all viewing angles.

The navigation luminaire shall have a cast bronze, marine grade aluminum, or brass body and be United States Coast Guard approved. Nuts, bolts, thumb screws, hardware, thread rods, pipe, hanger, and mounting bases which are exterior, shall be stainless steel (300 series) or bronze. Hardware on the interior of the lamp cavity shall be stainless steel or bronze.

The luminaire shall be optically sealed, mechanically strong, and easy to maintain. The luminaire shall be designed to operate on a 120 VAC power supply. The lamp cavities shall be either watertight, or they shall be weatherproof and bug proof. The lamp shall be easily accessible for relamping through gasketed doors which are held captive by means of hinges or a brass chain.

- (1) Dual Cavity Luminaire with Transfer Relay. The luminaire shall have two separate lamp cavities each equipped with fresnel lens and spring mounted, vibration resistant, medium, 600 watt, 250 volts, porcelain socket. The navigation light shall have two 120 volt, 75 watt, 20,000 hour life, clear long life incandescent lamps. The auxiliary lamp transfer relay shall be enclosed in its own cast aluminum housing with gasketed weather-proof cover mounted as shown on the plans. It shall be suitable for mounting on the navigational luminaire function with a line variation of 120 VAC \pm 20 percent and shall be protected from shock, vibration and humidity.
- (2) Luminaire with Automatic Lamp Changer. The luminaire shall be equipped with a single, six-place lampchanger which detects a lamp failure and automatically places a new lamp at the lens focal point with an accuracy of 0.5 in. (13 mm) of true center.

The lampchanger housing and lamp holder shall be accurately molded of corrosion resistant materials to assure long, trouble free operation. Gold plated or other Engineer approved contacts shall be supplied standard on all lampchangers. The lampchanger shall meet or exceed the requirements of the U.S. Coast Guard Specification #195, including vibration test at 5G's, shock test at 20G's, salt spray and immersion. Lamp changing actuation shall be accomplished by a motorized or spring driven, solenoid activated mechanism.

The lampchanger shall have solid state circuitry rated at 4 A to assure long life and dependable operation. Terminal blocks shall be color coded. The lampchanger shall operate dependably on a minimum of 8 V and a maximum of 14 V, AC or DC, without modification. A 120 V step-down transformer shall be furnished to provide the 12 V lamp source and shall be housed within the luminaire. The lamp shall be 12 V, 0.55 A, 4,000 hour life minimum, clear S-8 marine signal lamps with a prefocused base.

- (3) LED Luminaire. An LED light source shall produce the same candela output as a comparable incandescent luminaire. LED life for the optic shall exceed 50,000 hours and the end of life output shall not depreciate below 70 percent of its initial rating or a level established by the U.S. Coast Guard, whichever is greater. The LED array shall be mounted on a shock and vibration isolator in the center of the lens focal point.

Additional submittal information for all luminaires shall include, as a minimum, the following photometric test reports for both the red and green luminaires;

Full test report from an independent laboratory
Isocandela diagram
Chromaticity diagram
Candlepower values at every 2.5 degree interval
Candlepower curves shall be provided in the I.E.S. format
Calculated visibility service range in nautical miles for 11 viewing angles from -5 to 5 degrees

- (b) Aviation Obstruction Warning Luminaire. Luminaires shall be 12 in. (300 mm) beacon type and constructed to meet all FCC and FAA requirements for continuous service under all weather conditions. The housing shall be constructed of heavy cast aluminum with cast aluminum globe support rings to accommodate two 360 degree red fresnel lenses or red color filters. The lamp cavities shall be vented weather, and insect proof. The light shall have two 120 V, 620 W, 3,000 hour life, long life incandescent lamps. Each luminaire shall be operated by a beacon flasher according to FAA regulations without field adjustment. It shall be a two circuit control rated for 2.0 kW maximum, continuous tungsten load up to 131 °F (55 °C) ambient air temperature at 120 V. Flash rate shall be 30 FPM 2/3 on, 1/3 off duty cycle. Normally closed solid state relay configuration shall prove a "lights on" condition for fail safe operation. It shall be equipped with built-in surge and transient protection and furnished in a NEMA-3 enclosure.

SECTION 1068. CONTROLLER

1068.01 Lighting Controller. Lighting controllers shall be as follows.

- (a) General. The completed controller shall be an Industrial Control Panel under UL 508.
- (b) Enclosures.
- (1) Single Door Enclosure.
- a. Cabinet. The cabinet shall be single door design, fabricated from 0.125 in. (3 mm) thick Type 5052-H32 aluminum or AISI 304 stainless steel. The cabinet door frame shall be double flanged on all four sides. All external hardware shall be stainless steel. The cabinet shall have a NEMA 3R rating. Where no dimensions are indicated, the cabinet shall be sized to adequately house all required components with ample room for arrangement and termination of wiring. The back panel shall be designed so as not to exceed 60 percent of its fill capacity. Side panels shall not be used.
- b. Door. The door shall be constructed from the same material and thickness as the cabinet. The door, when larger than 4 sq ft (0.37 sq m) in area, shall be equipped with a three point latching mechanism with nylon rollers at the top and bottom. The door handle shall be stainless steel and shall have a minimum diameter of 1/2 in. (13 mm) and have a padlock provision. The door shall be sealed with a neoprene gasket. The door hinge shall be a heavy gauge continuous hinge with a 1/4 in. (6 mm) diameter stainless steel hinge pin. The hinge shall be secured with stainless steel carriage bolts and stainless steel nuts and locknuts. A linkage-arm system, of simple construction, shall be attached to the cabinet doors to secure them in a wide open position to insure safety

during field operations. The door shall be furnished with a rain and ice resistant standard traffic signal lock and two keys. A weatherproof pocket for prints shall be permanently attached to the inside of the door.

- c. Vent. The cabinet shall be equipped with a vent on top, designed to exclude moisture, dirt, and insects.
- d. Post Top Mounting. The cabinet shall be mounted a top a 4 in. (100 mm) rigid aluminum schedule 40 conduit stem anchored to a cast aluminum pedestal base constructed of ASTM B 26 or B 108 A444-T4, A356.0-T61, or 356-T6 cast aluminum with an access handhole cover. The stem and base shall be painted as specified for the cabinet. When post mounted, the cabinet shall have a stiffener plate bolted to the bottom of the enclosure.
- e. Base Mounting. Where indicated, the cabinet shall be mounted atop an enclosure base constructed from the same materials as the cabinet and of the same cross section as the cabinet. When specified, a steel transformer base shall be used for the enclosure base. When transformer base mounted, the cabinet shall have a stiffener plate bolted to the bottom of the enclosure. The transformer base shall be a non-breakaway base of a height and dimension as approved by the Engineer. The base extension shall be painted as specified for the cabinet. Where indicated, the foundation shall extend 12 in. (300 mm) above the surrounding grade to provide additional base extension.
- f. Work Pad. Except where the cabinet is facing a sidewalk, a poured, 4 in. (100 mm) thick concrete pad, not less than 48 in. (1.2 m) square shall be provided in front of the cabinet.

(2) Double Door Enclosure.

- a. Cabinet. The cabinet shall be of the dimensions shown on the plans and fabricated from 1/8 in. (3 mm) thick ASTM B 209, Alloy No. 3003-H14 aluminum. The cabinet shall comply with UL 65 and UL 50 and be reinforced with aluminum angles.
- b. Doors. The doors shall have stainless steel hinges. The door handle shall be stainless steel, a minimum diameter of 1/2 in. (13 mm) and be furnished with a rain and ice resistant lock. The doors shall be gasketed to exclude the entry of moisture, dirt, and insects. A linkage-arm system, of simple construction, shall be attached to the cabinet doors to allow securing in a wide open position during field operations.
- c. Insulation. When specified, the interior compartment shall be insulated on the inside of the sides, back, top, bottom, and inside of the doors with 1 in. (25 mm) thick polyisocyanurate rigid foam insulation board. The foam board shall have foil facers on each side. The side facing the interior of the cabinet shall have a white

tinted foil facer with a satin finish. The insulation shall have a minimum aged thermal resistance (R-value) of 8 at a 40 °F (4 °C) mean temperature. The insulation shall comply with Federal Specification HH-I-1972/1, Class 2.

- d. Mounting. The cabinet shall be mounted as indicated on the plans.
 - e. Work Pad. The working pad shall be according to Article 1068.01(b)(1)f above.
- (3) Wall Mount Enclosure. A wall mounted cabinet shall be according to Article 1068.01(b)(1), except when a stainless steel cabinet is specified, the following requirements shall be met.
- a. Cabinet. The cabinet shall be a wall mounted type, NEMA 4X, not less than 14 gauge stainless steel, Type 304 of the dimensions shown on the plans. The cabinet shall be sized to adequately house all required components with ample room for arrangement and termination of wiring. All seams shall be continuously welded with stainless steel weld wire.
 - b. Door. The front of the cabinet shall have a hinged stainless steel door equipped with a handle and latching device suitable for installing a padlock. The door shall be gasketed to exclude the entry of moisture, dirt, and insects. The cabinet door shall be made of not less than 14 gauge stainless steel, Type 304. A print pocket shall be attached to the inside of the door. The enclosure shall have a continuous stainless steel hinge welded to the door and to the enclosure. The door shall be held closed by means of captive clamps fabricated from 12 gauge stainless steel and held in place with stainless steel hex head bolts. The clamps are to incorporate a depth stop to insure uniform sealing pressure at all clamp points.

(c) Finish.

- (1) Unfinished Enclosures. Stainless steel enclosures shall not be painted.
- (2) Finished Enclosures. All aluminum enclosures shall be finished to a #3 polish.

When a painted finish is specified, the cabinet shall be cleaned before painting inside and outside with oxalic acid for five to ten minutes, or as otherwise recommended by the paint manufacturer and approved by the Engineer, to etch the metal surfaces.

The cabinet shall then receive two sprayed coats of white polyamide epoxy primer with a corrosion inhibitor applied inside and outside to all surfaces. The primer shall have a solids content, by volume of not less than 65 percent and each coat shall be applied to a thickness of 3 to 5 mils (0.076 to 0.125 mm).

All surfaces, interior and exterior, shall receive one final coat of silicone alkyd enamel paint. The finish paint shall have a solids content, by volume, of not less than 53 percent, and shall be applied to a thickness of 1.5 to 2.5 mils (0.038 to 0.064 mm).

The color of the finish paint shall be ANSI Standard No. 70 Sky Gray or as specified by the Engineer.

The finish shall be applied according to the paint manufacturer's recommendations and the manufacturer shall certify, in writing, to the Department, that the finish has been applied properly.

Submittal data submitted for approval shall address the requirement for the paint manufacturer's certification and shall include a standard, single source paint warranty by the paint manufacturer of the controller manufacturer to the Department.

- (d) Identification. The cabinet door shall have a stainless steel name plate of the dimensions and engraving indicated on the plans.
- (e) Control Components.

- (1) Time Switch. When specified, each controller shall have an electric time switch for automatic control of highway lighting circuits operating on a daily schedule having a fixed relation to sunrise and sunset. Turn-on and Turn-off times shall be adjustable ± 45 minutes from sunrise and sunset. All settings shall be field adjustable without special tools. Complete installation instructions, details on wiring connections, and information on time setting, manual operation, and necessary adjustments shall be furnished with each time switch.

The time switch shall be a microprocessor-based two channel controller with astronomic functions on both channels. The latitude shall be adjustable from ten to 60 degrees in the Northern hemisphere. Latitude changes shall be user settable without the use of special tools.

The time switch shall be programmable in an AM/PM format, with a resolution of one minute or better. The time switch shall automatically adjust for daylight saving time and have automatic leap year correction and operate on 240 VAC without the use of an additional transformer.

A battery backup shall be integral with the controller and shall use a nickel-cadmium battery. The battery backup shall provide power to the controller memory for a minimum of 72 hours in the event of power failures.

The published operating temperature range of the time switch shall be from -40 to 149 °F (-40 to 65 °C).

The time switch output relay contacts shall be rated sufficiently to handle the inrush current of two 200 A contactors. The time switch shall have a NEMA Type 1 enclosure as a minimum. The time switch

programming instructions shall be moisture proof and permanently affixed to the time switch or as otherwise approved by the Engineer.

(2) Photocell.

- a. General. The photocell shall consist of a metal electrode, molecularly bonded to a ceramic wafer, and coated with cadmium-sulfide. The photo cell shall be highly corrosion resistant without "Plastic dipping" with a nominal 0.75 sq in. (484 sq mm) in surface area. Color response of the cell shall be such that a maximum sensitivity is in the blue-green portion of the color spectrum.
- b. Switching Relay. The "On-Off" switching operations shall be accomplished by a normally closed contact which will be operated by means of an electro-magnetic relay. The response time shall be less than one second time delay for turn-on and three to thirty seconds time delay to prevent the "Turn-off" due to the light flashes of less than 10 foot candles (108 lux). Photocell shall be capable of less than one second time delay for both turn-on and turn-off when tested in full daylight. In the event of a circuitry failure, the lights will be turned on, or remain on.
- c. Surge Arrester. Overvoltage protection shall be provided for the control components by the means of an expulsion type surge arrester capable of passing the surge outlined in ANSI C 136.10, except follow current is 10,000 A.
- d. Chassis and Enclosure. The base of the unit shall be manufactured on a 3 in. (75 mm) wide, solid thermoset phenolic base. The bottom of the base shall have an integral, locking type, brass three prong plug according to ANSI C 136.10 and UL 773. The gasket shall be of a cross-linked polyethylene to assure moisture proof seal to the luminaire socket.
- e. Electrical. The control must be able to operate over the range of 105-305 V, 60 Hz AC. Its direct load rating shall be 1000 W Incandescent load and 1800 VA Mercury Vapor, High Pressure Sodium or other H.I.D. load.
- f. Environmental. The control shall be stable and reliable over an operating temperature range of -40 to 158 °F (-40 to 70 °C).
- g. Highway Lighting Operating Levels. Each control furnished shall be calibrated for a "Turn-on" setting of 0.5 to 2.1 ft candles (5.4 to 22.5 lux) of natural illumination and the "Turn-off" setting shall not exceed four times the "Turn-on" setting.
- h. Navigation and Aviation Operating Levels. Each photocell furnished for navigation or aviation obstruction lighting control shall be calibrated for a "turn on" setting of 35 foot candles (377 lux) and "turn off" shall occur at 52 foot candles (560 lux) of natural

illumination or according to the latest FAA and U.S. Coast Guard requirements.

- (3) Circuit Breakers. All feeders, branch circuits, and auxiliary and control circuits shall have overcurrent protection. The overcurrent protection shall be by means of circuit breakers.

Circuit breakers shall be standard UL listed molded case, thermal-magnetic bolt-on type circuit breakers with trip free indicating handles.

240 V circuit breakers shall have a UL listed interrupting rating of not less than 10,000 rms symmetrical amperes at rated circuit voltage for which the breaker is applied. 480 V applications shall have a UL listed interrupting rating of not less than 14,000 rms symmetrical amperes at rated circuit voltage.

Multi-pole circuit breakers larger than 100 A size shall have adjustable magnetic trip settings.

The number of branch circuit breakers shall be as indicated on the Control Cabinet detail drawing or as indicated in the lighting system wiring diagram which ever is greater plus two spare circuit breakers.

- (4) Contactors. Contactors shall be electrically operated, electrically or mechanically held, as specified, with the number of poles required for the service and with operating coil voltage as indicated. Ampere rating of contactors shall be not less than required for the duty shown and shall otherwise be rated as indicated.

Contactors shall be complete with a non-conducting inorganic, non-asbestos subpanel for mounting.

Electrically held contactors shall be used unless mechanically held contactors are specified. Electrically held contactors shall be NEMA, size 3, 2 pole, 60 Hz, 600 V, open panel mount type, normally open and electrically held and UL labeled.

Mechanically held contactors shall be complete with coil clearing contacts to interrupt current through the coil once the contactor is held in position.

The main contactor contacts shall be the double break, silver to silver type. They shall be spring loaded and provide a wiping action when opening and closing. The contacts shall be renewable from the front panel, self aligning, and protected by auxiliary arcing contacts.

The line and load terminals shall be pressure type terminals of copper construction and of the proper size for the ampere rating of the contactor.

A lever for manual operation shall be incorporated in the mechanically held contactor. Protection from accidental contact with current carrying parts when operating the contactor manually shall be provided.

The contactor operating coil shall operate at phase to neutral voltage. Single phase contactors shall be two pole devices with continuous rating for the amperage selected per pole.

Open and closed positions for mechanically held contactors shall be clearly indicated and labeled in permanent manner as approved by the Engineer.

- (5) Auto/Manual Switches for Mechanically Held Contactors. The cabinet shall be equipped with automatic and manual operating controls via two, single pole double throw switches, one being a maintained-contact manual-automatic selector switch and one being a momentary-contact manual on-off switch with a center rest position. Both switches shall be premium specification grade, rated for the applied duty but not less than 20 A at 240 V and each shall be mounted in a 4 in. (100 mm) square box with cover.

Selector Switch for Electrically Held Contactors. The selector switch shall have a glove-hand operating handle and industrial duty rotating mechanism. Contacts shall be rated 10 A make/break and continuous at 60 Hz, 600 V. The switch position shall be designated by a permanent name plate of metal or rigid laminated plastic. Switch shall be UL listed.

The control circuit shall have overcurrent protection as indicated and as required by NEC requirements.

- (6) Ground & Neutral Bus Bars. Separate ground and neutral bus bars shall be provided. The ground bus bar shall be copper, mounted on the equipment panel, fitted with 22 connectors of the type shown on the plans, as a minimum. The neutral bar shall be similar. The heads of connector screws shall be painted white for neutral bar connectors and green for ground bar connectors.
- (7) Interior Lighting and Receptacle. When specified, the cabinet shall have an auxiliary device circuit at 120 V single phase to supply a convenience receptacle and cabinet light. Where 120 V is not available directly from the service voltage, an outdoor dry type step-down transformer not less than 1 KVA shall be provided. It shall be according to Article 1068.02.

The auxiliary circuit, including transformer primary and secondary, shall have overcurrent protection according to NEC requirements.

The interior, 100 W incandescent lighting fixture with die cast guard shall meet the requirements of UL 1598 and be of the vaporproof enclosed-and-gasketed type. The light fixture shall be switched from a

single pole, single throw, 20 A switch. The switch shall be premium specification grade in a suitable 4 in. (100 mm) box with a cover.

A 20 A duplex receptacle, ground fault interrupting, premium specification grade shall be furnished in a 4 in. (100 mm) square box with cover, for 120 V auxiliary use.

- (8) Surge Arrester. The control cabinet shall be protected by a surge arrester meeting the requirements of Article 1065.02.
- (9) Insulated Back Panel. The cabinet shall have a non-conducting inorganic, non-asbestos subpanel to cover the back of the cabinet on which to mount control components. When specified no insulated back panel shall be used and all components shall be appropriately bonded and grounded to a metal mounting surface.
- (f) Wiring and Identification. Power wiring within the cabinet shall be of the size specified for the corresponding service conductors and branch circuits and shall be rated RHH/RHW, 600 V.

Control and auxiliary circuit wiring shall be rated RHH/RHW or MTW with jacket, 600 V. All power and control wiring shall be stranded copper. All wiring devices, such as bussbar, terminal blocks, lugs, etc. shall be copper. All wiring shall be tagged with self-sticking cable markers. When the contract drawings do not specifically indicate assigned wire designations, the manufacturer shall assign wire designations and indicate them on the shop drawings.

All switches, controls and the like shall be identified both as to function and position (as applicable) by means of engraved two color nameplates attached with screws, or where nameplate are not possible in the judgement of the Engineer, by the use of cloth-backed adhesive labels as approved by the Engineer.

The cabinet with all of its electrical components and parts shall be assembled in a neat orderly fashion. All of the electrical cables shall be installed in a trim, neat, professional manner. The cables shall be trained in straight horizontal and vertical directions and be parallel, next to, and adjacent to other cables whenever possible.

1068.02 Transformer, General Purpose. The transformer shall be dry type, encapsulated, and weatherproof so that it may be installed indoors or outdoors without additional housing. It shall have an enclosure for splices with provisions for weather tight conduit connections.

The transformer shall have four taps on the primary side, one at 2 1/2 percent, one at five percent, one at 7 1/2 percent and one at ten percent below rated voltage.

The windings shall be copper and the insulation shall be rated 180 °C or higher and temperature rise shall be rated 115 °C or lower. The transformer shall meet the applicable ASA and IEEE standards.

Mounting and back plates shall be of Aluminum Alloy 2024, 3003 or 6061. Bolts, nuts and washers shall be of Series 300 stainless steel. Bolts shall have hexheads. Nuts shall be hexagon and self locking. Washers shall be of the flat type.

1068.03 Navigation Obstruction Lighting Controller. The completed controller shall be an Industrial Control Panel under UL 508 according to Article 1068.01, except that the control circuit shall have dual control components where highway lighting is operated out of the same controller as navigation lighting. The control circuit shall be as detailed in the plans and approved by the Engineer.

Each photocell furnished for navigation or aviation obstruction lighting control shall be calibrated according to Article 1068.01(e)(2)h.

SECTION 1069. POLE AND TOWER

1069.01 Light Poles. All light poles shall be designed, fabricated, and furnished to provide a complete support system as follows.

The detailed design and fabrication of the pole shaft, arms, tenons, and attachments shall be according to AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals" current at the time the project is advertised. Light poles shall be designed for 90 mph (145 km/hr) wind velocity and a minimum design life of 50 years.

- (a) Loading. The following loading requirements shall include all possible luminaire and arm combinations up to and including the limits given. All other light pole configurations shall require the Contractor to submit for approval, detailed design calculations of each light pole including arm(s), luminaire(s), and any other attachments.
 - (1) Poles with Arms. Poles with arms shall be designed and manufactured to withstand loadings of up to and including a 75 lb (34 kg) luminaire having an effective projected area of 1.6 sq ft (0.15 sq m) on a single 4 to 15 ft (1.2 to 4.5 m) arm, and shall also withstand loadings of up to and including the same luminaire on each of two 4 to 12 ft (1.2 to 3.6 m) arms (twin) oriented 180 degrees apart, meeting the criteria of AASHTO as specified above.
 - (2) Poles with Tenon Tops. Tenon top poles shall be designed and manufactured to withstand loadings of up to and including twin 100 lb (45 kg) luminaires having an effective projected area each of 3.85 sq ft (0.36 sq m) on a twin tenon bracket. The tenon at the top of the pole shall meet AASHTO loading requirements for twin luminaires as specified above.

The pole shall be designed to withstand wind induced vibrations in the shaft and arm(s) so that no damage occurs to the shaft, arm(s), luminaire(s), and/or their component parts. The pole shall be coordinated with all luminaires to be free of susceptibility to harmful harmonics and vibrations. A dampening device, as an integral part of the shaft, shall be installed in the shaft to alleviate such vibrations in aluminum poles and all other poles as

necessary. The proposed vibration dampening device shall be included with the Contractor's submittal.

Deflection of the pole top as caused by the combined effect of wind and deadload referenced above shall be as required by AASHTO. Pole deflection and loading compliance, certified by the manufacturer, shall be noted on the pole submittal.

- (b) Mounting Height. The mounting height, for the purposes of pole fabrication, shall be defined as the vertical dimension between the bottom of the pole base plate to the center of the outboard end of the tenon on the arm(s). The mounting height for tenon top poles shall be to the top of the shaft. Breakaway devices shall not be included in the mounting height.
- (c) Shaft Design. The pole shall be designed with a minimum wall thickness to satisfy all design loading requirements. However, in no case shall the pole shafts have a wall thickness less than those shown on the plans. Reinforcing sleeves shall not be used.

Poles shall be straight with the centerline alignment not varying along the pole by more than 1/4 in./10 ft (6 mm/3 m) of pole length and not to vary by more than 0.1 percent of total pole height. The shaft shall be smooth circular (or nearly circular multi-sided), tubular, tapered design.

- (d) Pole Base. The base shall be welded to the bottom portion of the shaft. Anchor rod slots shall be provided in the base to accommodate the required bolt circle diameter.

Each base shall be equipped with four separate anchor rod covers. The covers shall be permanently attached and fit snugly to prevent rodent entry. On weathering steel poles, the covers shall not be in contact with the pole shaft.

- (e) Handhole. The pole shall have a reinforced handhole opening in the shaft as shown on the plans. The handhole frame shall be welded to the shaft.

The handhole cover shall be fastened to the frame utilizing flat, tamper resistant, pin-head drive screws. The screws shall be stainless steel, of sufficient length and shall be well coated with anti-seize compound.

- (f) Tenons. The tenon shall be coordinated with the luminaires being furnished for the contract so no more than 2 in. (50 mm) of the tenon is exposed.
- (g) Manufacturer Identification. Each pole shall have the manufacturer, lot number, and date of manufacture permanently stamped on the top of the base plate or other location approved by the Engineer.
- (h) Finish. Poles, arms, and attachments shall all be the same color and finish. All exposed surfaces shall be of a smooth, even texture, free from dents, kinks, ripples, imperfections, scratches, marks or other defects.

Aluminum and stainless steel poles shall not be painted. Except for weathering steel poles, steel poles shall not be painted unless they have been hot dip galvanized and the zinc surface has been specially prepared to accept paint.

- (i) Hardware. Hardware for aluminum poles shall be anodized aluminum alloy according to ASTM B211, 6061-T6 or Type 201 stainless steel. Hardware for steel poles shall be Type 201 stainless steel. All stainless steel hardware shall be coated with anti-seize compound.
- (j) Shipping. The pole shafts shall be shipped in bundles without any wrapping on the individual shafts or the entire bundle. Appropriate bundling materials shall be used to make a rigid, long lasting bundle capable of being handled, shipped and stored without shifting or breaking of contents.

1069.02 Aluminum Pole. Only aluminum poles with mounting heights of 40 ft (12 m) or greater may have a two piece shaft. Also, aluminum davit arm poles shall be a two piece pole (upper arm and lower shaft).

Aluminum tubing shall be according to ASTM B 210 (B 210M), alloy 6063-T6. The handhole frame for aluminum poles shall be fabricated from ASTM B 209 (B 209 M), alloy 6061 T651 or the same material used for the pole base. The base shall be a permanent mold casting of aluminum alloy according to Aluminum Association designations 356.0 or A356.0, with final temper T6 or T61. Tempers selected shall depend on forming practices of the pole manufacturer to satisfy the requirements of Article 1069.01(a).

Welding shall be by inert gas shielded arc (GMAW or GTAW). All welds shall be free from cracks and pores. All poles shall be heat treated after welding.

The shaft shall be spun drawn to a smooth, circular, seamless taper. All aluminum poles shall have a satin ground finish, 100 grit or finer.

The anchor rod covers shall be made from aluminum, according to ASTM B 108, alloy A356.0-T1, or ASTM B 26, alloy 443.0-F. A non-metallic anchor rod cover shall be used in high vandalism areas as approved by the Engineer.

(a) Mast Arm Style.

- (1) Arm. The mast arm shall be a truss style arm with upper and lower chord and reinforcing (bracing) members. The top chord of the arms shall have raceway openings extending through the bracket. Raceway openings shall be free of burrs and rough edges that may be injurious to the wires.

Exterior surfaces of the truss arms shall be free of all protuberances, dents, cracks, or other imperfections. The truss arm shall be made of aluminum alloy tube, round, seamless, according to ASTM B 221, 6063 T6.

The truss arms shall be supplied with fabricated aluminum brackets welded to the arms. All welds shall be heat treated after welding. The

arms shall attach to the shaft by a clamp type bracket with bolts, nuts, and lockwashers.

- (2) Pole Cap. Top of the shaft shall be enclosed with a removable aluminum cap of the same thickness as the pole shaft. The design of the cap shall be such that it shall not permit entry of water into the shaft.
 - (3) Grommets. Grommets openings at the top portion of the shaft shall be provided for wiring purposes through the top member(s) of the mast arm(s).
- (b) Davit Style. Each pole shall be a two piece assembly consisting of a round lower pole shaft and a round upper davit arm section. The pole-arm assembly shall be part of a coordinated system with components designed such that a common lower shaft will accept a variety of different length davit arms as follows.

4 ft (1.2 m) single
6 ft (1.8 m) single
8 ft (2.4 m) single
10 ft (3.0 m) single
12 ft (3.6 m) single
15 ft (4.5 m) single
4 ft (1.2 m) twin
6 ft (1.8 m) twin
8 ft (2.4 m) twin
10 ft (3.0 m) twin
12 ft (3.6 m) twin

Davit arms of various arm lengths shall be suitable for the lower shaft, regardless of mounting height and the limitation of types. The bend shall be carefully made so that the arm is free of kinks, wrinkles or other defects.

The davit arm, regardless of mounting height, shall be designed to slip fit over the lower pole shaft to provide a smooth, seamless transition. Submittal information shall include details of the slip joint.

The arm shall be coordinated with the luminaire furnished and produce a level mounting of the luminaire (up tilt not greater than 1.5 degrees) with the luminaire installed. Submittal information shall include confirmation of this coordination.

1069.03 Steel Pole. One-piece poles shall be furnished according to the following.

Galvanized steel poles shall be according to ASTM A 595, Grade A or B, ASTM A 572 Grade 55, or ASTM A 1011 Grade 55 HSLAS Class 2. The base plate shall be AASHTO M 270 Grade 50 or 50S (M 270M Grade 345 or 345S). The handhole frame and pole tenon shall be ASTM A 500 Grade C or ASTM A 513 Type 5 DOM1015 or 1020 tubing. The poles shall be galvanized according to AASHTO M 111. Steel selected shall have a silicon content less than 0.25 percent. The outer galvanized surfaces shall have a satin finish.

Stainless steel poles shall be according to ASTM A 269, Grade 201L, 304L, or 316L cold finished stainless steel, with a minimum yield strength of 60,000 psi (414,000 kPa) and 100,000 psi (689,000 kPa) minimum tensile strength after fabrication. The base plate and handhole frame shall be the same material as the pole.

Weathering steel poles shall be according to ASTM A 595 Grade C, ASTM A 606 Type IV, or AASHTO M 270 Grade 50W (M 270M Grade 345W). The base plate shall be fabricated according to AASHTO M 270 Grade 50W or HPS 50W (M 270M Grade 345W or HPS 345W). The handhole rim and pole tenon shall be fabricated of ASTM A 714 Class 2 pipe Grades I, II, or III.

Weathering steel poles shall be blasted according to SSPC - SP6 (commercial blast) and cleaned at the factory to remove all surface contamination. The surface area shall be free of any oil and other foreign elements. All weld spatter shall be removed, and the outside surface and base plate shall be an even texture, free from marks, burrs, sharp edges, or imperfections.

For all poles, a stainless steel ground lug shall be used. The anchor rod covers and handhole cover shall be made from 12 gauge minimum steel. A non-metallic anchor rod cover as approved by the Engineer shall be used on weathering steel poles.

- (a) Mast Arm Style. The mast arm, pole cap, and grommets shall be according to Article 1069.02(a), except as follows.

- (1) Arm. The truss style arm shall be fabricated from the same steel as the pole. Galvanized steel arms shall be fabricated according to Article 1077.03(a)(2).

The arm shall be supplied with fabricated steel brackets welded to the arms. The arms shall attach to the shaft by a clamp type bracket with bolts, nuts, and lockwashers.

- (2) Pole Cap. The top of the shaft shall be enclosed with a removable steel cap. The cap shall be finished to match the pole.

- (b) Davit Style. The davit arm pole shall be according to Article 1069.02(b), except as follows.

- (1) The poles shall be made of steel as specified above.

- (2) Stainless Steel Davit Pole. Each pole shall be a three piece assembly consisting of a flair base, pole shaft, and a short radius davit arm. The pole-arm assembly shall be part of a coordinated system as indicated above.

- (c) Tenon Top Style. The tenon shall be of the same material as the pole shaft.

The pole shall come complete with a twin tenon bracket (when required), and incidentals necessary to complete the installation.

A twin tenon bracket for a weathering steel pole shall be fabricated from 2 in. (50 mm) schedule 40 pipe 30,000 psi (208,000 kPa) minimum yield strength, painted with a prime coat of corrosion inhibiting polyamide epoxy and a finish coat of aliphatic acrylic polyurethane of a color to match aged weathering steel.

1069.04 Wood Pole. Wood poles shall be according to Article 1069.01 and the following.

Wood poles shall be Southern Yellow Pine, Western Red Cedar, or Douglas Fir preservative-treated according to the AWPAC Standard T1 and designated per Standard M6. Wood poles shall meet the requirements of ANSI O5.1. Poles shall be marked and have other documentation to confirm compliance with this requirement as well as the class designation.

The pole shall be selected for uniformity and straightness. Sweep shall be limited to one plane and one direction only. A straight line in the plane or maximum sweep joining the surface of the pole at top and 6 ft (1.8 m) above the base end shall not be more than 2 in. (50 mm) from the surface of the pole at any point. The pole shall be machine shaved to a smooth surface.

In addition to ANSI O5.1, poles shall have no indentations attributed to loading or handling slings that are 1/4 in. (6 mm) or more deep over 20 percent or more of the pole circumference, or more than 1/2 in. (13 mm) deep at any point. Other indentations or abrasions, for example, forklift damage, chain saw damage etc., shall not be more than 1/10 the pole diameter at the point of damage up to a maximum 1 in. (25 mm). Such damage will be permitted in an oversized section, where the excess of wood will be taken into consideration in evaluating the effects of the damage. In any case, the circumference for a given class shall still meet the ANSI minimum.

When a guy wire and anchor is required, they shall consist of the following.

- (a) 45 degree, 5/8 in. (16 mm), thimble, eye bolt
- (b) 1/4 in. (6 mm) thick, steel lift plate
- (c) Porcelain strain insulator rated not less than 6000 lb (2700 kg).
- (d) 8 in. (200 mm) helix, 5/8 in. (16 mm) rod thimble-eye screw anchor rated 6000 lb (2700 kg) 6 ft (1.8 m) long.
- (e) Clamps, three bolt type
- (f) Guy wire, 6000 lb (2700 kg) tensile strength galvanized or copper clad steel.

All bolts, plates, rods, clamps and guy wires shall be galvanized in accordance with ASTM A 153. Secondary racks shall be light duty galvanized steel with porcelain insulator spools spaced 12 in. (300 mm) apart and secured to the pole by two 5/8 in. (16 mm) through bolts, nuts, and washers, all galvanized.

- (g) Anchor guy shall be equipped with guy wire protectors.

1069.05 Composite Pole. Composite poles shall be according to Article 1069.01 and the following.

The pole shaft shall contain a minimum of 65 percent glass fibers by weight. The glass fibers shall consist of a commercial grade of "E" glass or better.

The pole shall be designed such that deflection of the pole tip from the vertical axis does not exceed one degree per 10 ft (3 m) of the nominal pole height as caused by the maximum design wind loading in combination with the deadweight moment of the luminaire(s), bracket, arm(s), and other attachments as applicable.

Pole deflection and loading calculations, certified by the manufacturer, shall be furnished to the Engineer as part of the pole submittal. Special notation shall be made to show that localized pole buckling has been considered and properly accounted for in the calculations.

The structural fibers and surfacing veil shall be constructed in a continuous process using a homogeneous resin mix to insure a strong molecular bonding of all adjoining layers.

The bottom portion of the shaft shall be fitted with an anchor base. The base shall be galvanized steel according to Article 1069.03. The base shall be permanently fixed to the shaft and sealed to prevent moisture ingress. The base shall be polyurethane coated to match the pole color and equipped with anchor rod covers of the same material and finish as the base.

The opening for the handhole shall be reinforced so as not to cause a weak point in the shaft. The handhole cover shall be of the same material and finish as the base.

A 1/2 in. (13 mm) tapped hole shall be provided in easy access inside the handhole for attaching a mechanical grounding connector. This bonding point shall be a part of and have good electrical continuity with the anchor base.

Poles may have an embedded stub section, as approved by the Engineer, for direct embedded poles. The minimum embedment depth for direct embedded poles shall be 6 ft (2 m). A wireway opening shall be located 15 in. (375 mm) below groundline. The opening shall be 2 1/2 X 18 in. (65 X 450 mm) in size and oriented to be parallel to the roadway unless otherwise directed by the Engineer. The embedded portion of the pole shall be designed to insure rotational stability under load and test data shall be submitted to document this capability.

In addition to the pole embedment requirements stated above, breakaway poles shall be manufactured according to and shall have a listing of approval by the FHWA to the current AASHTO breakaway requirements as stated in the "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals".

Glass fibers shall be covered with a surfacing veil consisting of a saturated polyester cloth of 15 mil (0.38 mm) minimum thickness. An outer protective layer

shall be provided of 10 mil (0.25 mm) minimum thickness of polyester resin with UV inhibitor and pigmented to the final color of the pole. The pole shall be covered with a final coating of polyurethane to a minimum thickness of 1.5 mil (0.04 mm). All thickness minimums shall be a dry coating thickness.

The shaft shall be a smooth circular, tubular, seamless, tapered design and shall be free of dents, kinks, ripples, voids, scratches or other defects. All fiberglass poles shall have a smooth consistent finish, free from marks and imperfections.

The pole shall have a groundline collar which shall protect the pole from abrasion by mowers and other equipment. It shall provide complete protection for the pole at groundline and extend up to the handhole without interfering with handhole access. The collar shall be securely fastened, rugged, removable, and UV resistant. It shall not detract from the aesthetics of the installation.

The pole shall have a minimum ten year written warrantee against delamination, fiber exposure, crazing, chalking, and shall cover all aspects of the finished pole against defect including fittings and hardware. The warranty shall be transferred to the Department.

- (a) Mast Arm Style. The arm shall be aluminum truss type according to Article 1069.02(a) and shall be painted with a powder coated process to match the pole.
- (b) Tenon Top Style. The tenon shall be according to Article 1069.03(c), except the tenon shall be made of galvanized steel according to Article 1069.03.

The finish of a twin tenon bracket shall match the pole.

1069.06 Pole/Unit Identification. Each pole, light tower, and underpass light shall be labeled as indicated on the plans to correspond to actual circuiting, and as designated by the Engineer. They shall be installed on each lighting unit pole shaft and on the underpass walls, or piers, as shown on the plans. Median-mounted poles shall have two sets of identification labeling oriented to allow visibility from travel in either direction. Lighting controllers shall also be identified by means of identification decals as described herein. Identification shall be in place prior to placing the equipment in service.

Identification of poles shall be made by application of letters and numerals as specified herein to an appropriately sized 1/8 in. (3.175 mm) thick stainless steel plate which shall be banded to the pole with two stainless steel bands.

Identification of painted poles shall be made by application of letters and numerals as specified herein via an adhesive approved by the paint manufacturer for the application.

Identification of luminaires which are not pole mounted, such as underpass luminaires, shall be done using identification brackets. In general, the brackets shall be mounted adjacent to and within 1 ft (300 mm) of their respective luminaires. The brackets shall be fabricated from 1/8 in. (3 mm) in. aluminum alloy sheet according to the dimensions shown on the plans. The bracket shall be bent so as to present the luminaire identification numbers at a 60 degree angle to the wall. The bracket shall

be attached to concrete walls with three 1/4 in. (6 mm), self drilling, snap-off type galvanized steel concrete anchors set flush with the wall, or power driven fasteners approved by the Engineer. The brackets shall be offset from the wall with 1/2 in. (13 mm) aluminum bushings. The structural steel shall not be drilled to attach the brackets. The luminaire identification numbers shall be applied to the bracket using the method described for identification applied to poles.

The letters and numerals for 60 ft (18 m) and less mounting height lighting units and underpass lighting units shall be 4 in. (100 mm) high, black, series "D" as described in the Federal Highway Administration's "Standard Alphabets for Highway Signs". Placement of numbers shall be as shown on the plans. The placement of the numbers shall be coordinated with the accident reference marker and handhole door as applicable. The letters and numerals shall be screened on silver-white, pressure sensitive, reflective, 4 1/2 x 4 in. (114 x 100 mm), Type A sheeting according to applicable portions of Section 1091. An alternate color scheme, such as black on yellow, shall be used as directed by the Engineer or indicated in the plans when the lighting system is not maintained by the Illinois Department of Transportation.

The letters and numerals for poles of a mounting height equal to and greater than 70 ft (21 m) shall be 9 in. (225 mm) high by 8 in. (200 mm) wide. The material of the decals and placement of numbers shall be as shown on the plans.

The letters and numerals for illuminated signs shall be 9 in. (225 mm) high x 8 in. (200 mm) wide. The material of the decals and placement of numbers shall be as shown on the plans.

Circuit identification for wood poles shall be made by the use of weather-resistant reflective letter tags in vertical slide in holders. Letter tags shall be reflective, black on yellow, with characters 3 in. (75 mm) high on tags nominally 2 1/2 x 3 5/8 in. (65 x 90 mm) in size. Slide in holders shall be aluminum and shall have both ends crimped after tags are inserted. The holders shall be attached to the poles with 1 1/2 in. (38 mm) aluminum nails as recommended by the tag manufacturer.

1069.07 Mounting Pad. When mounted on bridges, a vibration isolation mounting pad shall be included with the pole. The pad shall have the same shape as the bottom of the pole base with appropriate bolt holes and opening for the center of the pole. Included with the pad shall be four washers. The pad and washers shall be made from a rugged elastomeric material with a minimum thickness of 1/2 in (13 mm) or as recommended by the manufacturer. The ultimate breakdown of the pad and washers under compressive load shall be not less than 10,000 psi (69,000 kPa) for the specified thickness without extrusion or detrimental reduction in thickness. The material shall also have a Shore-A Durometer reading of not less than 85. The isolation washers shall be installed with galvanized steel washers of the same diameter and adequate thickness top and bottom to prevent overstressing of the isolation washer.

1069.08 Light Tower. Light towers (high mast poles) shall consist of any poles 80 ft (24 m) or more in length.

Each light tower shall be complete with internal, integral motorized lowering mechanism, luminaire ring, pole top hood, internal electric power cables, lightning

rod, luminaire counter-weight (when applicable), and all appurtenances required for a complete operating unit.

The design shall be based upon AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals" in effect on the date of invitation for bids. A 90 mph (145 km/hr) wind velocity and a minimum design life of 50 years shall be applied using Fatigue Category 1.

A minimum total combined luminaire weight of 600 lb (272 kg) shall be used plus a combined hood area and lowering ring weight of 400 lb (181 kg). The associated total projected area shall be 24 sq ft (2.23 sq m) and 10 sq ft (0.93 sq m) respectively. Additional weights and areas shall be added when necessary for such things as luminaire shields. Project specific weights and areas shall be used in the design calculations when they exceed the above minimums.

Light towers shall be designed and constructed so no structural member or other component is applied in excess of the manufacturer's recommended rating (when applicable) or the published rating, whichever is lower.

The design of the tower shaft shall achieve a maximum, fully loaded deflection at the top of the pole, which is not greater than the following percentage of the tower height.

Light Tower Maximum Deflection			
Tower Height in feet	Max Deflection % of Height	Tower Height in feet	Max. Deflection % of Height
160	13.70	110	7.80
150	10.04	100	5.30
140	7.80	90	4.50
130	6.02	80	3.50
120	10.75		

Tower Height in meters	Max Deflection % of Height	Tower Height in meters	Max. Deflection % of Height
49	13.70	33	7.80
46	10.04	30	5.30
43	7.80	27	4.50
40	6.02	24	3.50
36	10.75		

The light towers shall be of a height and luminaire capacity as indicated and be of the nonlatching ring support design.

The lowering device manufacturer shall furnish supervision for the installation of the light towers. The tower manufacturer or lowering device manufacturer shall warrant the entire coordinated assembly.

Specific requirements for the different components of a light tower are as follows.

- (a) Shaft. The tower shaft shall be a low deflection tapered shaft having polysided, circular, or elliptical cross sections. The shaft cross section at the

top shall be not less than 7.5 in. (190 mm) in diameter. The shaft cross section at the bottom shall not be greater than that which is compatible with the base plate bolt circle specified, and shall not be less than 24 in. (600 mm) in diameter for new installations. The minimum wall thickness of the bottom portion of the tower shaft shall be 0.2391 in. (3 gauge).

All tower shaft components shall be fabricated from high strength, low alloy, steel according to AASHTO M 270 (M 270M); ASTM A 595, Grade A or B; ASTM A 1011 (A 1011M); ASTM A 606, or ASTM A 808 (A 808M) with a minimum yield strength of 50,000 psi (345,000 kPa).

Galvanized steel poles shall be thoroughly cleaned and galvanized according to AASHTO M 111.

Each tower shaft shall be constructed of not more than the following welded or slip fitted sections.

Tower Height in feet	Maximum Number of Sections
130,140,150,160	4
90,100,110,120	3
80	2

Tower Height in meters	Maximum Number of Sections
40,43,46,49	4
27,30,33,36	3
24	2

Sections which are slip fitted shall have slip joints with a minimum overlap of 1.5 times the diameter of the bottom of the upper section at the slip joint. Towers having slip joint construction shall be prefitted and match marked at the factory and shall be shipped disassembled for assembly at the jobsite. Slip joints shall be marked to assure the 1.5 times diameter insertion is provided.

Each tower shaft shall be constructed with a handhole/access door for access to power connections and lowering mechanism equipment. The handhole shall be large enough to make the entire lowering mechanism assembly visible from an extended operating position and accessible for maintenance. The handhole shall be sized and arranged to permit removal of the lowering mechanism without excessive dismantling of the equipment. The handhole may be a reinforced opening in the pole shaft as detailed on the plans or may be a part of a flared shaft base assembly as approved by the Engineer. The flared base shall not be considered a separate section of the tower shaft. Minimum opening dimension for the handhole shall be 12 x 36 in. (300 x 900 mm).

The handholes in the pole shafts shall have rounded corners and shall be reinforced to maintain the original strength of the tower shaft. Flared base

assemblies shall maintain the strength of the shaft and have no nonround protrusions.

The handhole shall have a pocket door with a full-height piano hinge. A bolt through a door and frame eyelet shall not constitute an acceptable hinge. Hinges shall be heavy duty, suitable for the weight of the handhole door. The door/opening shall be gasketed in a manner which will prevent the entry of water into the pole and the door shall have a tight compressive seal employing a tubular gasket to assure compressibility. The gasket shall be permanently attached with stainless steel screws or bolts.

The handhole door shall be held closed with a 12 gauge captive adjustable, spring loaded, clamp assembly. The clamp assembly shall be held closed with deep slot screws. The clamps shall have a depth stop feature to insure uniform sealing pressure at all clamp points. A minimum of five clamps shall be used around the nonhinged sides of the door assembly. A padlock hasp and staple shall be provided for locking the door.

The door shall be equipped with an integral door stop mechanism. It shall be equipped with a linkage arm assembly to securely hold the door in the open position.

A rain shield shall be placed on or above the handhole to direct water away from the handhole. The shield shall be fabricated of the same material as the pole shaft, shall have rounded corners, and shall be permanently welded to the handhole frame or shaft. Details of the configuration and welding shall be included with the Contractor's submittal.

Each tower shaft shall have a handhole accessible ground pad welded to the shaft for connection of ground conductors. The pad shall be NEMA 2-hole pad and accessible with the lowering device installed.

The top of the shaft shall have a stainless steel ground lug welded to the tower shaft suitable for a bolted ground connection for a lightning rod.

A copper bonding jumper shall bond slip fit pole sections together with a flat copper cable and stainless steel ground lugs. A low profile bonding jumper shall be used to prevent snagging the roller/guide mechanism.

The base plate shall be factory predrilled (slotted) for the number and configuration of anchor rods.

The base plate shall have a round (disk) shape of the specified outer diameter or as otherwise approved by the Engineer. The minimum thickness of the base plate shall be 2.0 in. (50 mm).

The base plate shall be circumferentially welded to the tower shaft. A backer ring shall be used for this circumferential weld. All crevices at the backer ring shall be completely sealed to moisture and corrosion.

All tower shaft hardware, such as ground lugs, hardware for the handhole door, including the handle/latch mechanism, hinge and door stop, shall be

stainless steel. Ground lugs shall be protected by removable plastic plugs or caps.

(b) Welding.

- (1) Requirements. The Contractor shall submit the manufacturer's welding procedures to the Engineer for approval prior to fabrication. The welding symbols and complete information regarding location, type, size, welding sequence, and WPSs shall be shown on all shop drawings.

Welds shall be smooth and thoroughly cleaned of flux and spatter and be according to the AWS. Minimum preheats for welds shall be 100 °F (40 °C) for fillets, 150 °F (65 °C) for seams, and 225 °F (110 °C) for circumferential welds.

Circumferential welds, including top flange welds, shall be full penetration welds.

Longitudinal welds shall have a minimum of 60 percent penetration, except the longitudinal welds on both the male and female shaft sections shall be full penetration welds within a distance of two diameters of overlap joints.

All full penetration welds shall be inspected for soundness by the ultrasonic method and all partial penetration welds shall be inspected by the magnetic particle method.

Weld procedure specifications for seams and circumferential welds shall be qualified according to Section 4, Part B of AWS D1.1. Charpy V-Notch (CVN) impact specimens shall be tested according to Table III-1 (note 2) of Appendix III for minimum values of 25 ft lb at 40 °F (34 J at 4 °C). Fillet weld procedures shall be tested according to Table 4.4 of AWS D1.1.

- (2) Inspection. In addition to manufacturer's own welding inspection, the Contractor shall have welding inspected by an independent Certified Welding Inspector (CWI). The selected inspector shall be approved by the Engineer before any inspecting is performed. The NDE inspector(s) shall be independent nondestructive testing inspector(s), certified as level II in RT, UT, and/or MT as applicable.

The methods for testing full penetration and partial penetration welds by the independent welding inspector(s) shall be the same as specified above.

The independent welding inspector shall send the test results directly to the Engineers, as follows: Illinois Department of Transportation, Attn: Engineer of Structural Services, 2300 S. Dirksen Parkway, Bureau of Bridges & Structures, Springfield, Illinois 62764 and to the applicable Regional Engineer.

(c) Light Tower Finish. Light tower finishes shall be as follows.

- (1) Painted Tower. Painted towers shall be completely painted, including the handhole, handhole door, base plate, mounting plate and all other elements attached to the shaft. Tower inside shall be painted with organic zinc rich primer coat only.

The paint system to be used shall be included with the submittal for approval by the Engineer. The three coat paint system shall consist of an organic zinc rich primer, epoxy or urethane intermediate coat, and a urethane finish coat. The finish coat shall be applied to the outside surfaces only and shall match Federal Standard Number 595 - Color Number 26307 (Hanford Gray). Each coat shall be a different color and all paint shall be shop applied under controlled conditions.

The paint system shall be applied according to the applicable portions of Section 506 and the paint manufacturer's recommendations. Stainless steel and electrical or mechanical components shall not be painted.

The dry film thickness of each coat shall be as recommended by the paint manufacturer for continuous exterior exposure, as required by the product data sheet and as approved by the Engineer. The Contractor shall furnish in writing to the Engineer the paint manufacturer's normal warranty and certification that the paint system has been properly applied.

Field touch up painting of towers shall be according to the paint manufacturer's recommended procedures with paint supplied for that purpose.

- (2) Weathering Steel Towers. Surfaces of the weathering steel tower that are not to be painted shall be properly cleaned and prepared in order to form a uniform patina. These surfaces shall be free of any paint, weld splatter, oil, grease, or other foreign matter. Preparation shall be according to SSPC-SP-10 (Near White Blast) to a surface profile of 1 to 3 mils (25 to 75 μm). The inside surface of the pole above the bottom 10 ft (3 m) need only be prepared according to SSPC SP6 (Commercial Blast) to a surface profile of 1 to 3 mils (25 to 75 μm).

Weathering steel towers shall have the bottom 10 ft (3 m) painted, inside and out, including the handhole, handhole door, base plate, mounting plate and all other elements welded to the shaft. The paint shall be applied according to Article 1069.08(c)(1). In addition to the bottom 10 ft (3 m) of the tower, the male and female section of the slip joint(s) and the head frame plate shall also be painted. The color of the finish coat shall match Federal Standard Number 595 - Color Number 20045 (approximating weathering steel).

- (3) Galvanized Steel Towers. Galvanized steel towers shall be hot-dip galvanized including the handhole, handhole door, base plate, mounting

plate and all other elements welded to the shaft according to AASHTO M 111.

- (d) Head Frame. Each tower shall be equipped with a head frame assembly to support and guide the luminaire ring assembly. The head frame and luminaire ring shall have a positive mating interface with the proper seating force applied to each guide pin when in the home position.

The guide pin housing for each support cable shall have a flared bottom section to help seat the cable guide pin. The cable guide pin shall be inserted a minimum of 4 in. (100 mm) into the guide pin housing. The cable shall be protected against wear in the head frame when in the fully seated (home) position.

The head frame plate and attached components shall be fabricated of the same type of steel as the tower shaft or of Type 201L stainless steel. It shall then be hot dipped galvanized according to AASHTO M 111 or painted as specified for the tower shaft or fabricated from stainless steel.

The head frame shall have a pulley support and two pulleys for each lift cable.

The head frame shall have a power cable pulley arrangement placed between and roughly equidistant from two support arms, and allow a minimum cable bending radius of not less than 6 1/2 in. (163 mm). The head frame shall have a minimum diameter of 36 in. (1 m).

Pulley sheaves shall be constructed to allow associated cables to ride freely within pulley grooves and cable guides shall be incorporated to prevent cables from riding out of pulleys.

Attachment hardware, pins, pulley axles and the like used in the head frame assembly shall be stainless steel. Pulleys shall be made of stainless steel and have permanently lubricated sealed bearings or self lubricating bronze bushings.

The head frame assembly shall be equipped with an aluminum hood with a minimum thickness of 0.125 in. (3 mm). The aluminum hood shall protect the operating head frame components from damage or deterioration from weather. The hood shall be attached with a minimum of eight stainless steel bolts and have safety tether of stainless steel chain to hold the hood to the head frame plate when the hood is removed.

The head frame assembly shall be match marked to its tower shaft and shall be attached to the shaft by stainless steel hardware.

All penetrations through the hood and head frame assembly shall be sealed to prevent the entry and nesting of birds and mice. The head frame plate shall be vented to permit pole ventilation. The vent opening shall be covered with a stainless steel screen.

- (e) **Luminaire Ring.** Each tower shall be provided with a luminaire ring suitable for the quantity, type, and orientation of the luminaires specified. The ring shall mate/align with the head frame and shall be coordinated relative to seating force. The diameter of the ring shall be kept to a minimum while being coordinated with the diameter of the tower shaft to insure smooth operation of the lowering device and a ring that can be fully lowered for luminaire maintenance.

The ring shall be designed to accommodate a minimum of eight tenons, each supporting a highmast luminaire. The tenons shall be adequately spaced to accommodate a shield or visor on each luminaire. Counterweights shall be provided as needed. The weight of the ring and all attachments shall be balanced and evenly distributed to the lift cables.

A fully enclosed and continuously welded metal ring shall be furnished. An open ring design will be allowed if the Engineer determines the open ring will be as structurally rigid, weather and corrosion resistant, and has the same life expectancy as a fully enclosed ring. The fully enclosed luminaire ring shall facilitate ease of wiring to the arms by removable gasketed doors. The open ring design shall incorporate a steel retainer strap welded to the ring at a 1 ft (300 mm) maximum spacing to keep the cord properly aligned with the ring. Both the enclosed and open ring design shall be free from protrusions or sharp edges that could damage the cord insulation.

The ring shall be equipped with bumpers, rollers, or other shock-absorbing mechanism to guide the ring during the raising/lowering operations. The guide mechanism shall be a spring loaded design to minimize shock to the luminaire during raising and lowering and shall be made of materials with corrosion resistance equivalent to stainless steel. The guide mechanism shall not damage or mar the finish of the tower and shall be designed to pass freely over the pole bonding strap(s).

Arms for the attachment of luminaires shall be standard 2 in. (50 mm) diameter tenon arms. The arms shall be attached to the ring in a secure manner either by welding or by means of stainless steel bolts, nuts, lock washers and hardware such that a permanent rigid attachment is achieved. Arms shall be approximately 24 in. (600 mm) in length, coordinated with luminaire size and configuration and shall be arranged so that down lighting or multi-mount luminaires are accommodated as specified. Multi-mount luminaires shall have flexible, weatherproof conduit to transition the cord from the end of the tenon arm to the luminaire.

The ring shall lower to 4 ft (1.2 m) above the bottom of the tower base plate or 5 ft (1.5 m) above the surrounding grade, whichever is lower. A stop mechanism shall be incorporated into the lowering device to prevent conflict of the transition plate in the top of the pole which could cause stress to the lift cables or damage to the plate.

The ring shall be equipped with an enclosed wire raceway and a stainless steel terminal box built according to NEMA 3R requirements for wiring of the luminaires. The box shall be equipped with a hinged door and latch or with captive stainless steel closure hardware acceptable to the Engineer and an

external special fixed-mount plug with a retained cap according to Article 1069.08(o), to accept a test power connection when the ring is in the lowered position.

The terminal box shall have a waterproof breather valve mounted on top and 1 in. (25 mm) diameter vent hole drilled in the bottom and permanently sealed from insects with a stainless steel screen. The box shall be equipped with fuses and fuse blocks for fuses per Article 1065.01(b).

The box shall contain a terminal strip with identified terminals for connection of the main power cord, luminaires, and the test power receptacle. The ring shall facilitate ease of wiring to the arms by the use of removable gasketed covers. Arms shall be factory or field wired using No. 12 AWG, Type SOOW. The cord shall have three conductor, flexible CPE jacketed construction according to UL Standard 62 and be MSHA approved. The cord shall be rated 600 V and -58 to 221 °F (-50 to 105 °C). Each conductor shall be No. 12 AWG stranded annealed copper per ASTM B 174 with EPDM insulation.

Wiring shall be color coded according to Article 1066.02. Wires shall be installed to all luminaire arms and extend 6 ft (1.8 m) longer than their respective tenon arm and shall be trained back into the arm. The arm shall then be sealed with a protective cap for shipment to the jobsite. All ring wiring shall be tagged with wire markers at both ends.

Ring designs that incorporate flexible conduit to the terminal box shall use stainless steel conduit fittings with stainless steel wire mesh grips. Stainless steel wire mesh grips shall also be used with all cord grips that support the weight of the main power cord to the ring.

The luminaire ring shall be factory checked and marked for proper positioning and luminaire orientation. Catalog cuts and shop drawings shall indicate the orientation of the luminaire ring, handhole, and bolt circle in relation to each other on a single drawing. The orientation of the terminal box on the ring shall be over the tower handhole or as close to that location as possible.

The fully enclosed luminaire ring and attached components shall be fabricated of the same type of steel as the tower shaft or of Type 201L stainless steel. If it is not fabricated of stainless steel, it shall then be hot dip galvanized according to AASHTO M 111 or painted according to Article 1069.08(c)(1). An open ring system shall be fabricated of Type 201L stainless steel.

- (f) Lowering and Support Mechanism. The support shall be of the nonlatching design. The lowering and support scheme shall be of the two cable or three cable type as specified.

The lowering and support mechanism shall include, but not be limited to the support cables, hoist cable, internal drive unit and all accessories and appurtenances for a coordinated operating system.

Three cable mechanisms shall incorporate three support cables joined at a transition plate to a single hoist cable wound around a single hoist winch. The transition design shall utilize thrust bearings in order to prevent twisting of the hoist and support cables and to assure smooth winding of the cable on the winch. The entire transition plate shall be visible in the tower handhole when the ring is raised and fully seated.

Two cable mechanisms shall incorporate two support/hoist cables wound around a dual winch assembly. The design shall be such to prevent twisting of the cables and to assure smooth winding of the cables on their respective winch and to prevent binding on the inside of the tower shaft.

The hoisting system shall be securely mounted and the lower assembly, i.e. motor, winch, mechanical clutch, gear reducer, etc., shall be designed to allow ease in removal of the equipment via the tower handhole without dismantling the system. Individual components shall be accessible and removable without the removal of other components.

The device shall tightly position the luminaire mounting ring against the head frame assembly by applying a seating force of 300 lb (1.3 kN) minimum, to be distributed among the seating/interface points. There shall be a positive indication at the handhole or on the head frame that the required force has been applied, visible from the extended operating position away from the handhole and not under the ring.

The mechanism shall be equipped with a multipoint safety chain and hook assembly to hold the luminaire ring in place during maintenance. All hardware shall be stainless steel. Chains may be galvanized or stainless steel. Two chains are required for each tower with each chain having sufficient strength to safely hold the ring in its fully seated position.

All components of the support system shall be designed with the appropriate safety factors to hold the ring, cables, and lowering device. Safety verification shall be provided with the Contractor's submittal. The system shall be designed so that unbroken power cable, suspension and/or hoist cable can be replaced from ground level.

- (g) Support and Hoist Cables. Cables (wire rope) shall be manufactured from Type 304 or Type 316 stainless steel having a carbon content of 0.09 to 0.15 and shall be a stranded assembly coated with a friction-limiting non-corrosive lubricant.

Cables shall be 7x19 wire strand and have no strand joints or strand splices. Cables shall be manufactured and listed for compliance with military specification MIL-W-83420B, Type 1, Composition B.

Cable terminals shall be stainless steel compatible with the cable and as recommended by the cable manufacturer. The terminals, swaging, etc. shall meet the requirements of military specification MIL-T-781.

The support cables shall each be not less than 3/16 in. (5 mm) in diameter and the hoist cable shall not be less than 5/16 in. (8 mm) in diameter, for a

three support cable system. For two cable systems, the support/hoist cables shall each be not less than 1/4 in. (6 mm) in diameter.

As part of the tower shop drawings and product data submitted for approval, support and hoist cable information shall be provided. The information shall include the following.

- (1) Catalog information to confirm sizing, stranding and other specified requirements.
- (2) Evidence of listing as military specification cable as specified.
- (3) Certification of compliance with all specification requirements made by the cable manufacturer.
- (4) Copies of recent test reports made on identical cable indicating compliance with military specification requirements. The test reports shall include as a minimum, the following.
 - a. Breaking Strength test.
 - b. Endurance test.
 - c. Stretch test.
 - d. Test load.
 - e. Chemical Composition.
- (5) For all termination devices used on the cable, a written certification by the cable manufacturer that the proposed device is approved and compatible with the required military specification.

(h) Winch. The winch shall have a drum suitable for the support/hoist cables, arranged to provide smooth winding of the cable and to prevent slippage. The drum shall be stainless steel or cast/ductile iron and shall have a diameter not less than 18 times the diameter of its respective cable (wire rope). The winch drum shall be designed with cable guides for a smooth cable take-up of level lays and to prevent the cable from riding over the drum flange. The drum shall have the end of the cable attached by means of a swaged connection and one full layer of cable shall be wound on the drum when the ring is in the fully lowered position. The drum axle shall be supported at both ends.

(i) Gear Reducer. Each assembly shall incorporate a gear reducer having a reduction ratio which will prevent free fall of the luminaire ring upon failure or disengagement of the drive unit and which will produce a travel rate of 10 to 15 ft (3 to 4.6 m)/minute under normal operation.

The unit shall have a worm gear which is totally enclosed in a lubricating reservoir. The lubricant shall have a viscosity range suitable for proper operation in ambient temperatures from -40 to 120 °F (-40 to 49 °C). The

worm shall be manufactured of case hardened ground alloy steel or cast iron. The unit shall have provisions to verify the oil level in the gear box.

The gear shall be of bronze alloy and keyed to the output shaft. The worm gear shaft and output shaft shall be mounted on antifriction bearings.

- (j) Clutch. The mechanism shall incorporate a mechanical clutch, installed between the winch/gear reducer and the motor. The clutch shall be of mechanical type, in a sealed cast metal housing. The clutch torque shall be factory calibrated and coordinated with the electric motor. The clutch shall act to limit the seating force of the raised ring to 300 lb (1.3 kN).
- (k) Motor. The electric motor shall be matched to the load and torque characteristics required for a loaded luminaire ring and shall not be less than 1 hp. The motor shall have built in over current protection and reset switch. The switch shall be installed to have easy access inside the tower handhole for inspection and testing.

The motor shall be totally enclosed fan cooled (TEFC), shall be reversible to operate the lowering mechanism in both directions, and shall be of rated voltage compatible with power supplied to the tower.

Submittal information shall include complete motor data, including, but not limited to the following.

- (1) Manufacturer
- (2) Nameplate Rated Watts (Horsepower)
- (3) Rated Voltage
- (4) Full Load RPM
- (5) Full Load Current
- (6) Locked Rotor Current
- (7) NEMA Design Letter
- (8) Insulation Class
- (9) Torque Data
- (10) Dimensional Data
- (11) Over Current Protection Data
- (12) Calculations to verify the compatibility of the drive unit components (motor, gear reducer, clutch and winch). Calculations shall verify the 300 lb (1.3 kN) seating force.

- (l) Ring Lowering Controls. The control shall incorporate a reversing motor starter or reversing control switch. The motor starter shall be sized NEMA 1 as a minimum and shall be full voltage, rated 600 V, 2-pole reversing type with arc-extinguishing capabilities, and shall have a coil voltage as specified. The reversing control switch shall be a drum switch with a minimum rating of 3 hp.

Either control device shall be capable of being operated remotely, at a distance of 25 ft (7.5 m) from the tower. The remote, "dead man" style switch with lever control shall be in a non-metallic, impact resistant, NEMA 4 enclosure. It shall have momentary contacts, up-stop-down settings, and require constant pressure by the operator to energize the circuit.

- (m) Power Supply. The power supply to the tower shall feed through a standard 2-pole fuseholder according to Article 1065.01 and connect to a surge arrester according to Article 1065.02 before terminating at the tower main breaker. The tower main breaker shall be housed in a stainless steel NEMA 4 enclosure mounted on the inside of the handhole pocket door. The main breaker shall have an external position indicating, trip free operating handle having padlock provisions and shall be labeled by two color engraved nameplates clearly marking the "RESET", "ON", and "OFF" positions.

The main circuit breaker shall be a molded case, 2-pole, thermal magnetic, bolt-on type having a UL-listed interrupting rating of not less than 14,000 rms symmetrical amps at 480 V. The breaker shall be sized for the motor but shall be a minimum of 30 A.

- (n) Flexible Cord. All control cord in the tower handhole shall be Type SOOW portable power cord and shall be no smaller than No. 12 AWG with ground. The cord shall have a multi-conductor, flexible CPE jacketed construction according to UL Standard 62 and be MSHA approved. The cord shall be rated 600 V and -58 to 221 °F (-50 to 105 °C). Each conductor shall be No. 12 AWG stranded annealed copper per ASTM B 174 with EPDM insulation. The cord shall be rated for extra hard-usage service and shall be oil, chemical, and UV resistant.

The power cord in the tower handhole, starting at the surge arrester and running to the luminaire ring, shall be Type W industrial grade portable power cord and shall be No. 8 AWG or larger. The cord shall have a multi-conductor, extra flexible CPE or CSPE jacketed construction with reinforced fillers to maintain a smooth round surface according to ICEA S-75-381, NEMA WC 58, UL Standard 1650, and be MSHA approved. The cord shall be rated 2000 V and -40 to 194 °F (-40 to 90 °C). Each conductor shall be No. 8 AWG rope lay stranded annealed copper per ASTM B 172 or ASTM B 173.

All cords shall be reeled and neatly stored when housed in the tower handhole and arranged so as not to interfere with the lowering mechanism or closing of the handhole door. All circuits shall include a green insulated equipment grounding conductor of the same size as the circuit phase conductor.

- (o) Connectors. Plug and receptacle connectors shall be “pin and sleeve” type to allow quick connections of the feed from the main breaker to the power cord at the transition plate, luminaire ring, and motor control circuit. Connectors shall be four pole, four wire, 600 V, 60 A, load-break, weatherproof devices and be according to UL Standard 1682 and IEC Standard 309. Both plug and receptacle shall be complete with retained flap-type protective end cover. The feed from the main breaker shall have a socket insert to minimize contact exposure.

All connections to the power cord shall include a stainless steel wire mesh strain relief. All terminations of the power cord in an enclosure shall be through a stainless steel, watertight cord connector using a water tight sealing bushing. At the surge arrestor in the handhole, the power cord shall be sealed in a heat shrink, multi leg boot.

- (p) Lightning Protection. A copper clad steel lightning rod of 1/2 in. (13 mm) minimum diameter shall be attached to the head frame. It shall be centered over the pole, penetrate the hood, and extend a minimum of 3 ft (1 m) above the hood. The rod shall be threaded and coupled at the point of hood penetration to facilitate the removal of the hood.

A flexible copper braid connector of #2 copper equivalent shall be installed between the lightning rod (air terminal) and grounding lug at the top of the tower shaft. Good metal-to-metal contact shall be assured by using UL listed compression style connectors specifically approved for the purpose.

A minimum #4 solid bare soft drawn copper grounding electrode conductor shall be attached between the grounding electrode at the foundation and the ground pad in the handhole. The grounding electrode shall be according to Section 806.

SECTION 1070. FOUNDATION AND BREAKAWAY DEVICES

1070.01 Light Pole Foundation, Metal. Metal foundations shall be fabricated from material new and unused in any previous application and shall be galvanized according to AASHTO M 111. The manufacturer shall provide a certification that the materials are new and meet the specified requirements and shall accompany the submittal.

Metal foundations shall be fabricated from steel.	
Baseplate	AASHTO M 270, Grade 36 (M 270M, Grade 250)
Shaft	ASTM A 252, Grade 2, Phosphorus 0.04% max., Sulfur 0.05% max.
Helix Screw	AASHTO M 270, Grade 36 (M 270M, Grade 250)
Pilot Point	AASHTO M 270, Grade 36 (M 270M, Grade 250)

Metal foundations shall be fabricated with two wiring entry slots parallel with the shaft axis and aligned with base plate faces 180 degrees apart. Continuous slots up

and through the base plate will not be acceptable. The shaft of the foundation shall be socketed into the top plate and welded on both sides.

Foundation shaft diameters, baseplate size, shaft length and bolt circles shall be as detailed on the plans. Foundations shall be fully coordinated with specified poles.

Fully threaded rods shall be furnished with the foundations and shall be according to Article 1006.09, Grade 105 (Grade 725) with washers and nuts. Rods shall be 1 in. (25 mm) diameter and galvanized for the full length.

Metal foundations shall come complete with galvanized steel plates or plugs to fill any penetrations in the base plate which are in addition to the four threaded stud holes and the center wireway opening.

1070.02 Anchor Rods. Anchor rods shall be according to Article 1006.09, Grade 105 (Grade 725) and full length galvanized with washers and nuts.

1070.03 Light Tower Anchor Rod Assembly. Anchor rods, washers, and nuts shall be according to Article 1070.02. Anchor rod information shall be submitted for approval and shall be fully coordinated with the tower manufacturer's requirements.

Anchor rod nuts for all towers shall be the self-locking type with steel inserts.

1070.04 Breakaway Devices. Breakaway devices shall be as follows.

(a) Breakaway Couplings

- (1) General. Breakaway couplings shall be manufactured of galvanized steel. Certification shall be submitted from the supplier that the device used under the conditions of the particular design meets the AASHTO breakaway specification. Certification shall include test results performed by the manufacturer, supplier or others. If test results have been previously approved by a letter from the FHWA, a copy of the approval letter from FHWA should accompany the certification. The coupling shall not alter the bolt circle of the pole.

The breakaway device shall be vandal resistant and shall not adversely affect the light pole installation and maintenance or decrease the resistance of the light pole to non-collision type of design loading. The breakaway device shall be field attachable and detachable.

- (2) Breakaway Coupling Cover. The breakaway device shall have a cover enclosing the space between the bottom of the pole base plate and the foundation.
 - a. Aluminum Skirt. The cover shall be an aluminum skirt of a two piece design made of ASTM B 209 Alloy 3003-H14 or 5052-H32, 0.080 in. (2 mm) thick. The enclosure shall fit snugly around the breakaway devices between the bottom face of the pole base plate and top of the foundation. Vertical or horizontal movement of the enclosure will not be acceptable.

- b. **Fiberglass Shroud.** When specified, the cover shall be a molded fiberglass shroud. The shroud shall be designed as a one piece fiberglass enclosure, capable of being installed over the base of the light pole and breakaway couplings, as shown on the plans. When installed on existing poles, the shroud may be a two piece assembly designed to be permanently joined in a manner which is tamper-resistant as approved by the Engineer. The shroud shall be dimensioned in a manner such that it will fit over light pole base designs with a bolt circle and shaft diameter as shown on the plans, and lateral movement shall be no greater than required to allow easy installation. The Contractor shall submit all dimensions necessary to confirm a proper fit. The shroud color shall be applied in a manner applicable to current industry practice for this type of material and use. The color shall be as approved by the Engineer. The Contractor shall submit samples of colors and materials for selection.
- c. **Stainless Steel Wire Cloth.** The stainless steel wire cloth mesh shall have a maximum opening of 1/4 in. (6 mm) and a minimum wire diameter of AWG No. 18 (1.2 mm) with a minimum lap of 6 in. (150 mm) to enclose the void between the pole base and the foundation. The lap shall be tied together with stainless steel wire.

(b) **Transformer Base**

- (1) The breakaway device shall be a cast and welded aluminum transformer base type pole base. The breakaway device shall have a listing of approval by FHWA to AASHTO breakaway requirements. This shall require compliance to "Standard Specifications of Structural Supports for Highway Signs, Luminaires and Traffic Signals" published by AASHTO. Submittal information shall document the approval listing.
- (2) The device shall be approximately 17 in. (430 mm) high and shall have a large fiberglass or polyethylene access door of a color to match the base finish which shall be held in place with a button-type tamper resistant stainless steel screw or other means approved by the Engineer. The polyethylene access door shall be fabricated from a high density polyethylene. The door shall withstand temperature extremes of -76 to 150 °F (-60 to 65 °C). Ultraviolet light inhibitors shall also be incorporated into the door material. The door shall be gusseted and have tabs on the bottom to lock into the transformer base door frame.
- (3) The appearance of the breakaway device shall be of such general configuration as not to detract from the aesthetic value of the light pole. The device shall have a natural aluminum finish.
- (4) **Bolt Circle Size.** The transformer base shall come in two standard sizes.
 - a. 11.5 in. (290 mm) Pole Bolt Circle Devices. Breakaway devices for poles having nominal 11.5 in. (290 mm) bolt circles shall

accommodate bottom (foundation) bolt circles ranging roughly 10 to 12 in. (255 to 300 mm) and shall accommodate top (pole) bolt circles ranging roughly 10.5 to 12 in. (265 to 300 mm).

- b. 15 in. (380 mm) Pole Bolt Circle Devices. This device shall be furnished in one of two styles. The straight base device shall be furnished unless otherwise specified.
 1. Flared Base Device. The bottom foundation bolt circle shall have a range of 15 to 17 in. (380 to 430 mm) and shall accommodate top (pole) bolt circles having a range of 13 to 15 in. (330 to 380 mm).
 2. Straight Base Device. The bottom foundation bolt circle shall have a bolt circle of 15 in. (380 mm) and shall accommodate top (pole) bolt circles of 15 in. (380 mm).

TRAFFIC SIGNALS

SECTION 1071. RESERVED

SECTION 1072. EMERGENCY VEHICLE PRIORITY SYSTEM

1072.01 Emergency Vehicle Priority System.

- (a) System Requirements. The system shall operate over an ambient temperature of -22 to 165 °F (-30 to 74 °C) and in 0 to 95 percent relative humidity.

All logic and timing circuitry shall be solid state. All printed circuit assemblies shall be according to NEMA Standards for Traffic Control Systems, TS 2.

- (b) Light Transmitter. The transmitter shall transmit a pulsed high intensity light energy in a forward direction. The on/off condition shall be controlled by an on/off switch and shall be indicated by a light located adjacent to the switch.

The transmitter shall operate on 10 to 15 VDC input voltage, but shall not be damaged by input voltage surges up to 25 VDC.

The transmitter shall not generate voltage transients on the battery input line which exceed the battery voltage by more than 4 V.

- (c) Light Detector. The detector shall be capable of receiving high intensity light energy from one or both of two axially opposed directions, as indicated on the plans.

The internal circuitry of a detector unit shall be potted in a semi-flexible compound for moisture resistance.

The standard operating amperage shall be less than 6 A.

Internal circuitry shall prevent electrical output due to steady state ambient light.

The confirmation beacon shall be a weatherproof floodlight fixture with a 150 W long life floodlight.

- (d) Light Detector Amplifier. The detector amplifier shall be a solid state design.

The detector amplifier shall have at least two channels and the capability of interfacing with another detector amplifier for channel expansion.

The detector amplifier shall have LED indicator lights to indicate power on, light energy being received, and channel called.

The detector amplifier, when actuated, shall continue to operate for at least six seconds after any interruption of light energy.

The detector amplifier shall sustain no permanent damage when subject to a transient produced by the discharge of a 10 microfarad capacitor charged to 600 V and applied to the AC line.

SECTION 1073. CONTROLLER

1073.01 Traffic Actuated Solid State Digital Controller. A traffic actuated solid state digital controller shall be according to NEMA Standards for Traffic Control Systems, TS 2. Additionally, the controller shall be of digital design having eight independent phases and four overlap phases and shall be according to the following.

- (a) Definitions.

- (1) Anti-backup. A programmable controller logic function inhibiting a call on a leading left turn phase (1, 3, 5 or 7) from being served prior to crossing the barrier if the opposing through phase (2, 4, 6, or 8) is on, and thus avoiding left turn trap.
- (2) Minimum Red Indication (Red Revert). Provision within the controller to assure a minimum RED signal indication in a phase following the YELLOW CHANGE interval of that phase.
- (3) Offset. The time relationship expressed in seconds or percent of cycle length, determined by the difference between the starting point of the coordinated phase green and a system reference point.
- (4) Phase. The green, change, and clearance intervals in a cycle assigned to any independent movement(s) of traffic.

(b) Design.

- (1) Menu Driven Programming. The controller programming software shall utilize a menu structure displayed on a screen. The software shall display on one screen any phase associated parameter for all eight independent phases. The controller shall be capable of being programmed from the front key panel.
- (2) Electrically Erasable Programmable Read Only Memory (EEPROM) Data Storage. All controller programming data shall be retained utilizing EEPROM technology.
- (3) RS 232 Connector. The controller shall be provided with a RS 232 connector to interface with a peripheral device.
- (4) Internal Time Base Coordination. The controller unit shall have internal time base coordination as specified in Article 1073.01(c)(1).
- (5) Internal Preemption Feature. The controller unit shall preempt the signal according to Article 1073.01(c)(2).
- (6) Data Key and Ethernet Port. The controller shall have a standard data key and Ethernet port. The data key shall be used for controller database backup, transfer, and management.

(c) Functions.

(1) Internal Time Base Coordination.

The controller shall contain a sufficient memory to retain and implement the following programs and shall be manually programmable by a user from the front panel.

- a. At least four cycle lengths, four splits, and three offsets.
- b. 16 day programs.
- c. ten week programs.
- d. 30 special event programs.
- e. Automatic daylight savings and leap year adjustments.

The controller shall contain a calendar/clock that can be readily set to the nearest week, day, hour, minute, and second of the year. The clock shall use the power line frequency as a time base, and shall use a rechargeable battery powered, temperature compensated oscillator when power is interrupted. The capacity of the battery shall be sufficient to provide 100 consecutive hours of standby operation after 48 hours of normal operation. The clock accuracy shall be 0.005 percent or better when it is on standby power.

The controller shall provide a split interval for every phase of the controller. Phase split time shall be entered directly in percent of cycle length or in seconds. The yield and force-off points shall be calculated automatically.

The controller shall have the capability to omit any phase during any program. This feature shall be internal to the controller and shall be selectable by the user from the front panel.

The offset reference point shall be at the beginning of the coordinated phase green. The offsets shall be in seconds or percent of cycle length and shall be calculated automatically when the cycle length is changed.

The controller shall have built-in diagnostics to detect both coordination and hardware failures. In case the coordination is not functioning, the controller shall revert to the free operation mode.

The controller shall provide real time display of its stored coordination information. The display shall be easily readable outdoors. The controller shall display the following data.

Coordination parameters.

Clock data (week of year, day of week, hour, minute, and second).

Current operational status.

The controller shall upload and download the complete coordination settings.

- (2) Internal Preemption Feature. The controller shall implement up to six preemption plans according to a preset priority. The method of activation used in preemption shall be equipped with a fail safe feature.

Railroad interconnected controllers shall provide for immediate track clearance green re-service upon receipt of each subsequent pre-empt demand. During this re-service all normal vehicle clearance intervals, including red-revert, shall be respected. Pedestrian clearance during railroad pre-emption will be limited to a flashing don't walk interval in length to the vehicle yellow clearance interval and shall time concurrently with the yellow clearance.

- (3) The controller shall have the following features.

The controller program shall include the option of single entry or dual entry mode of operation.

The overlap phases shall be programmable from the front panel or by a method approved by the Engineer.

The controller shall cross switch detectors from a left turn phase to an associated through phase according to NEMA dual ring operation.

The controller shall interface internally with the transceiver of the same manufacture.

The controller program shall include an anti-backup feature.

The controller shall have a programmable minimum RED indication (red-revert) feature of up to 9.9 seconds.

1073.02 Flasher Controller.

- (a) Flasher. The flasher shall be NEMA Type 3 and be according to NEMA Standards for Traffic Control Systems, TS 2. LED indicators shall be provided to track the flasher output.
- (b) Housing. The flasher shall be enclosed in a weatherproof, cast aluminum cabinet of adequate size. One 15 A circuit breaker shall be provided for the incoming power line.

1073.03 Transceiver. A transceiver shall be microprocessor based and shall be according to NEMA Standards for Traffic Control Systems, TS 2 and the following.

- (a) Design. The transceiver shall provide the following.

Frequency shift keying or time division multiplexing techniques.
 Half duplex or full duplex communications.
 Parity and error checking diagnostics to assure transmission and reception of valid data at 1200 baud minimum.
 Keyboard entry of system address from the front panel.
 Transmitter frequency stability over the NEMA operating temperature range of ± 5 Hz.

- (b) Functions.

- (1) The transceiver shall be capable to receive the following command data from a master controller and convey them to the local controller.

Cycle lengths, offsets and splits
 Special functions
 Coordinated or free mode
 A systemwide sync

- (2) The transceiver shall monitor the status of the following functions and transmit the information to a master controller.

Local controller phase green
 Local coordinator operation
 Conflict Flash
 Manual flash
 Preemption
 System detectors (a minimum of four) and local detectors (a minimum of eight)

- (3) The transceiver shall allow downloading and uploading of the local intersection data base. The preemptor and overlap data will not be downloaded.
- (c) Housing. The transceiver may be integral to the controller or furnished as a separate module in the controller.

1073.04 Master Controller. A master controller shall be microprocessor based and shall be according to NEMA Standards for Traffic Control Systems, TS 2 and the following.

- (a) Operation Modes. The master controller shall be capable of operating in any of the following modes.
 - (1) Traffic Responsive. Pattern selection shall be based on traffic conditions measured by system detectors.
 - (2) Time of Day/Day of Week. Preprogrammed selection of patterns shall be based on time of day/day of week.
 - (3) Manual. Pattern selection shall be based on operator command.
- (b) Design
 - (1) Transceiver. The master controller shall contain a transceiver which shall provide transmission of all required pattern and command data to the local intersection controllers and shall allow reception of status and detector data from each local controller within the control area. The data rate among the master controller and the local controllers shall be 1200 baud minimum.
 - (2) In-Cabinet Modem. The controller cabinet shall contain a 2400 baud auto dial/auto answer modem. It shall accept Attention (AT) command set. The data rate shall be 2400 baud minimum.
 - (3) Telephone Line Terminal. The controller cabinet shall be provided with an outdoor network interface for the termination of the telephone service. It shall be mounted to the inside of the cabinet suitable to provide access for the termination of the telephone service and shall be equipped with a standard three electrode heavy duty gas tube surge arrester.
 - (4) Surge Protection. The controller cabinet shall be equipped with surge suppressers and noise filters for the telephone line and the modem's power receptacle. These shall be three stage variety containing avalanche diodes, metal-oxide varistors and gas tube arrestors.
 - (5) RS-232 C Interface. The master controller shall be equipped with two RS-232 C interfaces for external communication with a remote personal computer and with a local device such as a portable personal computer or a printer.

- (6) Keypad Data Entry and Front Panel Display. The master controller shall be programmable via a front keypad entry. A front panel display shall be provided on the master controller for operator monitoring of input values and output commands including.

Parameter values

Current operating status

Pattern command status

System sensor activity

Cycle synchronization

Local controllers and system detectors operation status

(c) Functions.

(1) Operational Capacity

- a. Number of Local Controllers. The master controller shall have the capacity to command and supervise a minimum of 24 local controllers.
- b. Number of System Detectors. The master controller shall have the capacity to monitor at least 32 sampling detectors for all controlled intersections and up to 16 sampling detectors for a single intersection. The detectors used as sampling detectors shall be selectable from dedicated sampling detectors or local intersection detectors in any combination.
- c. Number of Timing Plans and System Commands. The master controller shall be capable of implementing a minimum of 30 timing plans. Each plan shall consist of a combination of cycle length, offset, and split. The master controller shall be capable of a minimum of four system commands including the commands for controller free or coordinated operation and for controller MUTCD flash operation.
- d. Number of Program Events. The master controller shall be capable of providing a minimum of 150 program events. A program event shall consist of a selected time of day, day of the week, and week of the year for which a timing plan, out of a minimum of 30 timing plans, shall be put into effect.
- e. Number of Logged Events. The master controller shall be capable of logging a minimum of 100 events under the buffer(s) with a time and date stamp for each event. This data shall be stored in the master controller and retrievable through the remote monitoring microcomputer.

(2) Operation Modes.

- a. Traffic Responsive Operation. Pattern selection shall be based on user selectable validated volume, occupancy, or concentration data obtained from system detectors to compute the following functions.

Level of arterial traffic
Directionality of arterial traffic
Ratio of a set of detectors to a second set of detectors
Ratio of side street to arterial traffic

Preferential and/or hierarchical transfer of patterns shall be accomplished via programmable user-specified threshold values.

- b. Time of Day/Day of Week Operation. The master controller shall be according to the internal time base coordination as specified in Article 1073.01(c)(1). It shall be possible to select any system pattern from the master controller on a preprogrammed time of day/day of week basis with automatic daylight savings and leap year adjustments. In addition, it shall be possible to specify the following on a time of day/day of week basis.

Special function system commands
Crossing artery synchronization
Traffic responsive computation period
System detector and speed report interval

- c. Manual Operation. Pattern selection shall be based on operator command.

(3) Remote System Controlling, Reporting, Monitoring, and Diagnosing.

The master controller shall be capable of being programmed and monitored from a remote site through a computer program running under Microsoft Disk Operating System (MS DOS™) or under Windows Operating System on a IBM compatible personal computer (PC) either stand alone or a station in a local area network (LAN). The IBM compatible PC shall utilize a 486 series microprocessor or a next generation of microprocessor. The programming and monitoring from the remote site shall include the following functions.

- a. Remote System Control. The master controller shall enable upload and download of all master programming as well as local controller programming.
- b. Remote System Reporting.
 - 1. System Status Report. When requested a system status report shall be generated. The report shall indicate current operating mode and pattern for local controllers.
 - 2. System Failure Report. This report shall indicate the off line local controllers and the failure time and mode. The master controller shall communicate the local controller faults to the remote site.

3. System Detector Failure Report. All failed system detectors shall be listed on this report.
 4. System Detector Report. The volume and occupancy data from any of the system detectors, tabulated by 15 minute intervals for a 24 hour period shall be included on this report.
 5. System Fault Alarms. The master controller shall have the capability of programmable fault reporting by dialing out to assigned telephone number(s). A minimum of three levels of programmable alarms shall be provided.
 6. System Operation Report. This report or an equivalent shall indicate the time of changes in operation mode and the timing patterns for the past 48 hours.
- c. Remote System Monitoring.
1. Number of Systems Monitored. The remote system software shall be capable of monitoring a minimum of 99 separate systems.
 2. Data Compatibility Between the Software Versions. Data from earlier versions of the remote system monitor software shall be compatible with or easily translatable for use in newer version upgrade. Manual reconstruction of data base shall not be required with each upgrade. All software located in controllers and master controllers, which are currently in use in the field and new, shall be compatible with all current or new versions of the remote system monitor software. The version of the software for all master and local controllers shall be uploaded and viewed during each upload and download. As part of a data base set up, the remote system monitor software shall not require master and local controller software versions to be manually programmed, except for the master and local controller model numbers or types. All firmware changes made at any master or local controller shall be transparent to the remote system monitor software.
 3. Intersection and System Graphics. The supplier of the master controller shall create intersection and system graphic displays and program all software parameters for each intersection to be monitored through the master controller, including complete viewing and control capabilities. Each intersection display and system display shall show a mode of operation, that is, traffic responsive, time of day, or free, and the timing plan in effect for the coordinated operation, that is, cycle length, split, and offset.

The intersection displays shall be an accurate graphical representation of the intersection geometry, lane configuration, signal phasing, and detector layout. The display shall contain

the correct alignment of the crossing streets and include the correct number and types of lanes. Depending on the intersection geometry, the display shall show left turn lanes, dual left turn lanes, multiple through lanes, and right turn lanes. The display shall contain indicators for all used controller phases, associated pedestrian phases, and overlap phases, and for local detectors actuation, and system detectors actuation.

The system displays shall be an accurate graphical representation of the signal system. The system display shall contain all system intersections. The display shall contain indicators for all used phases at all intersections and system detectors actuation.

d. System Diagnostics.

1. Local Controller Diagnostic. At a minimum the master controller shall diagnose and report local controller flash fault by reporting the conflict monitor fault logging information for the current fault.
2. System Detector Diagnostic. Each system detector shall be monitored for constant calls, absence of calls, or erratic output. Diagnostic values shall be user programmable for all detectors on a system basis. System detectors which fail the diagnostic test shall be automatically deleted for volume and occupancy calculations. The event of failure occurrence shall be stored for reporting. Upon resumption of satisfactory operation, detectors shall automatically resume input to volume and occupancy calculations.

SECTION 1074. CONTROL EQUIPMENT

1074.01 Digital Time Switch. The digital time switch shall be according to NEMA Standards for Traffic Control Systems, TS 2, and the following.

- (a) Functions. The digital time switch shall be capable of opening and closing a circuit at specific times of a day and shall be capable of omitting circuit operation during certain days of the week. It shall be possible to set any opening or closing to the nearest minute, the open period for as short as 90 minutes and the close period for as short as 30 minutes. It shall also be capable of providing four "on" and four "off" operations in each 24 hour period. All settings shall be field programmable using a key pad.
- (b) Designs. The digital time switch shall contain a precise clock based on a seven day program, settable to the nearest second of the week, day, hour, and minute. The 60 Hz power line frequency shall be the basic time reference for the clock. The clock shall automatically adjust for daylight savings and leap years.

The digital time switch shall have a battery back-up feature to protect against loss of timing in case of a power failure. During power failure, the battery operation shall keep the unit in time for a period of up to 100 hours. The unit clock accuracy shall be 0.005 percent or better when it is on battery power and shall assume normal operation upon resumption of power.

- (c) Special Features. The digital time switch shall include the following light emitting diodes indicators to confirm the applicable status outputs.

(1) ON - OFF.

(2) LINE POWER - BATTERY.

A time of day display shall be provided which is easily readable outdoors. Each unit furnished shall be labeled as to the function it controls.

1074.02 Pedestrian Push-Button. Pedestrian push-button assemblies shall be ADA compliant, vandal and weather resistant, be pressure activated with minimal movement, and cannot be stuck in a closed or constant call position. A red latching LED and audible tone shall be provided for confirmation of an actuation call.

- (a) Housing. The pedestrian push-button housing shall be constructed of aluminum alloy according to ASTM B 308 6061-T6 and powder coated yellow, and furnished with suitable mounting hardware.
- (b) Latching LED. The normal state of the LED shall be off. When the push button is pressure activated, the LED shall be lighted and remain on until the beginning of the walk phase. The latching relay shall be mounted in the signal cabinet, controlling two pedestrian phases.
- (c) Actuator. The actuator shall be stainless steel with a solid state electronic Piezo switch rated for a minimum of 20 million cycles with no moving plunger or moving electrical contacts. The operating voltage shall be 12-24 V AC/DC. The actuator's nominal operating force shall be approximately 1 lb (4.45 N).
- (d) Sign. The pedestrian information sign shall be according to the MUTCD. The legend on the sign shall either be all words or a combination of words and symbol to match the pedestrian signal. The sign base shall be sheet aluminum according to Article 1090.02.
- (e) Pedestrian Station. Stations shall be designed to be mounted directly to a post, mast arm pole or wood pole. The station shall be aluminum and shall accept a 3 in. (75 mm) round push-button assembly and a regulatory pedestrian instruction sign according to MUTCD, sign series R 10-1 through R 10-4.

1074.03 Controller Cabinet and Peripheral Equipment.

- (a) Cabinet. A controller cabinet shall house a controller and peripheral equipment by providing a secure space and by guarding against inclement weather. The cabinet shall be made of an aluminum alloy and shall be of

sturdy construction. Only one cabinet shall be permitted at one intersection for all traffic control equipment.

- (1) Cabinet Type. The cabinet specified on the plans shall be determined on the basis of the average volume of the control equipment to be installed in the cabinet. The various types of cabinets shall meet the following.

Type	Approx. Volume cu ft (cu m)	Police Door	Mounting	Ventilation	Remark
I				Reserved	
II	5.0 (0.14)	Yes	Post Top	Filtered Air Intake and One Thermo-Statically Controlled Fan	
III	11.5 (0.33)	Yes	Ground Mount	Filtered Air Intake and One Thermo-Statically Controlled Fan	For Traffic Actuated Controller
IV	29.0 (0.82)	Yes	Ground Mount	Filtered Air Intake and Two Thermo-Statically Controlled Fans	For Traffic Actuated Controller. Back Panel with Minimum 12 Load Switch Positions.
V	44.0 (1.25)	Yes	Ground Mount	Filtered Air Intake and Two Thermo-Statically Controlled Fans	For Traffic Actuated Controller. Back Panel with Minimum 12 Load Switch Positions.

- (2) Weather Resistant Requirements.

- a. Heavy-duty Door Gasket. Heavy-duty gaskets shall be provided around door openings to make a weather-tight seal for the protection of the enclosed equipment.
- b. Caulking of Cabinets. Ground mount cabinets shall be caulked along the entire perimeter of the base with a waterproof, nonhardening exterior compound prior to setting on the foundation to ensure a water, dust and insect proof seal.
- c. Screened Vent. A standard furnace filter shall be mounted on the inside of the cabinet door and shall be designed to prevent the entrance of insects, blowing rain and snow. It shall be securely attached to the cabinet and shall be removable by simple tools to permit cleaning and replacement.
- d. Cabinet Exterior. The cabinet surface shall be smooth, free of marks and scratches and provide an unpainted aluminum finish.

(3) Cabinet Design.

- a. Multiple Door-Stop. The cabinet front door shall be capable of being held at various angles by a stop-and-catch mechanism.
- b. Door Handle. The door handle shall rotate outward from the locked position. The operation of the handle shall not interfere with the key, police door or any other cabinet mechanism.
- c. Door Locks and Keys. The front door shall be equipped with a standard or a tumbler lock and the police door shall be provided with a police type lock. The front door lock shall not open by a standard police key. Additionally, two sets of keys shall be provided with each cabinet.

(4) Transient Voltage Surge Suppression. The cabinet shall be provided with transient voltage surge suppression. Transient surge suppression unit leads shall be kept as short as possible and ground shall be made directly to the cabinet wall or ground plate as near as possible to the object being grounded. All transient surge suppression units shall be tested and certified as meeting this specification by an independent testing laboratory. One copy each of the full testing report shall be submitted to the Engineer.

- a. Surge Suppressor. The suppressor protecting the solid state controller, conflict monitor, and detection equipment shall consist of two stages: stage one which shall include a controller cabinet AC power protection assembly and stage two which shall include AC circuit protection.

The design of the stage one suppressor shall be modular and it shall be installed in such a way that it may be removed and replaced with the intersection under power and in flashing operation. It shall have a permanently mounted and wired base and a removable circuit package. The stage one suppressor shall have two LED failure indicators for power 'on' and suppression 'failure' and shall be according to the following.

Stage One Suppressor	
Properties	Criteria
"Plug-in" suppression module	12 pin connector assembly
Clamp voltage	250 V at 20,000 A typical
Response time	Less than 5 nanoseconds
Maximum continuous service current	15 A at 120 VAC 60 Hz
High frequency noise attenuation	At least 50 dB at 100,000 Hz
Operating temperature	-40 to 185 °F (-40 to 85 °C)

If the controller assembly includes a system telemetry module or remote intersection monitor, the status of the stage one suppressor shall be continuously and remotely monitored by an appropriate alarm circuit.

The stage two, high speed, solid state, transient suppressor shall protect the system from transient over voltage without affecting power at the load. It shall suppress transients of either polarity and from either direction (source or load). The suppressor shall have a visual "on" indicator lamp when the unit is operating normally. It shall also have a UL plastic enclosure, a four position terminal strip for power connection, and it shall utilize silicon avalanche diode technology. The stage two suppressor shall be according to the following.

Stage Two Suppressor	
Properties	Criteria
Nominal service voltage	120 V at 50/60 Hz
Maximum voltage protection level	± 330 V
Minimum voltage protection level	± 220 V ± 5 %
Minimum surge current rating	700 A
Stand by power	Less than 0.5 Watts
Hot to neutral leakage current at 120 V RMS	Less than 5 μ A
Maximum response time	5 nanoseconds
Operating and Storage temperature	-4 to 122 °F (-20 to 50 °C)

- b. Detector Loop. The shield and the drain wire of the lead-in cable shall be grounded at the controller cabinet end to the closest cabinet wall or ground plate. At the other end, the shield and the drain wire shall be insulated to prevent possible grounding.
- c. Interconnection, 120 VAC. A replaceable spark gap gas type cartridge shall be provided between each incoming conductor and ground.
- d. Interconnection, DC or Low Voltage Balanced Line. The unit shall be capable of withstanding a minimum of 100 repeated 2,000 A (8 x 20 microsecond wave form) surges. The response time shall not exceed 100 nanoseconds with a duty cycle of 0.01 percent for 100 A surge. The voltage clamp shall be 30 V.

(5) Miscellaneous Cabinet Function Requirements.

- a. Signal Flash in Absence of Conflict Monitor. The cabinet shall contain circuitry that will place signal into flashing mode of operation if the conflict monitor is disconnected.
- b. Thermostatically Controlled Exhaust Fan. The cabinet shall be equipped with a thermostatically controlled exhaust fan. The fan

shall have a minimum air delivery capacity of 100 cfm (2.8 cu m/min) and shall be mounted on self-lubricating ball bearings. The thermostat control shall be adjustable between 91 and 113 °F (33 and 45 °C) and shall be set to turn the fan on at 95 °F (35 °C).

- c. Power Outlet and Light Fixture. Within the cabinet shall be provided a grounded three wire, 120 V, ground fault interrupter duplex outlet and a cabinet-door-switchable light fixture with a standard incandescent soft light bulb of 55 to 70 W.
- d. Signal Control Switches. The switches shall be provided in the controller cabinet for the following mode of operation.

Controller: ON-OFF
 Controller: STOP TIME-RUN-REMOTE
 Signals: NORMAL-MUTCD FLASH (with controller on)

The switches shall be provided in the police door compartment for the following mode of operation.

Signals: ON-OFF (The switch operation shall not depend on the position of AUTO-FLASH switch.)
 Signals: AUTO-FLASH (with controller in stop time)
 Signals: AUTO-MANUAL

- e. Railroad Interconnection. Railroad interconnected controllers and cabinets shall be fully tested and approved in the equipment suppliers facility prior to field installation. Three copies of the complete cabinet wiring showing all connections including railroad interconnect circuit shall be furnished.

Cabinets shall be equipped with a labeled test switch for the railroad interconnected pre-emption line which shall place a call in the controllers railroad pre-emption routine and also shall acknowledge power to the interconnect line. The switch shall resume to normal position upon release.

The terminal facility shall be wired so as to provide supervision of all essential pre-emption components. This wiring shall cause the facility to transfer to or remain in flashing operation in the event any critical component is missing, not connected or failed. The preemption interface relay shall be wired so as to be in the energized state during normal (non-pre-empt) operation. Each critical element such as controller harnesses and interface relays shall be wired to form a series loop which must be complete for normal operation.

A method of supervising the individually shielded three pair cable or individually braided three conductor cable, interconnecting the traffic and railroad facilities shall provide flashing operation during failed cable conditions. Upon detection of a failed railroad

interconnect the controller shall provide one track clearance green interval and shall enter flashing operation at the end of track clearance red interval. Such flashing operation shall be manually reset. The supervision circuit shall be capable of detecting failure of the supervision circuit components themselves, and shall provide fail-safe operation upon such failure.

The interconnect to the railroad facility shall be such that demand for pre-emption begins when the railroad flasher begin to flash and ends when railroad gates begin to rise.

A Department approved method of controller security shall be implemented to assure data integrity and to preclude changes to critical data. The method shall include a means for the controller to continuously verify controller/cabinet Cyclical Redundancy Check (CRC) or Terminal and Facility (T&F) Signature match. The CRC or T&F Signature shall be developed based on preemptor entries, unit data (including phases in use, sequence and ring structure, etc.), overlap assignment and timing, firmware version, and any special memory content necessary to proper operation. Where data is stored in a data module or on a computer chip, a spare data module or computer chip shall be provided to the Engineer.

(b) Peripheral Equipment.

- (1) Conflict Monitor. A conflict monitor shall be according to NEMA Standards for Traffic Control Systems, TS 2, including the specified monitoring of signal indication conflict, absence of RED signal voltage, and voltage. The conflict monitor shall be according to the following.
 - a. Number of Programmable Channels. The conflict monitor shall have either 12 or 18 fully programmable channels according to NEMA Type 12 or Type 18 unit respectively. The number of channels shall be sufficient to monitor all of the used vehicular phases, associated pedestrian phases, and overlap phases.
 - b. Simultaneous Dual Color Conflict. The conflict monitor shall detect simultaneous display of two separate colors in each signal face, except the simultaneous display of "circular red" and "green turn arrow", or "circular red" and "yellow turn arrow" as signal indication conflict.
 - c. Operation Upon Conflict Detection. Upon detection of signal indication conflict, absence of RED signal voltage or specified voltage deviation, the monitor shall place the signals into emergency flashing operation. The controller shall stop timing in the condition that existed at the moment of conflict and shall remain in stop time, except for the emergency flash caused by specified voltage deviation, until reset by maintenance personnel. The monitor channel indicators shall display the fault status and the field output status at the time of the failure.

- d. Fault Log. The conflict monitor shall store a minimum of last 20 fault status and the corresponding field output status with the date and time stamps in a non-volatile memory.
 - e. Liquid Crystal Display (LCD). The conflict monitor shall simultaneously indicate the field output status for all the programmed channels on the LCD. When interrogated, the conflict monitor shall indicate the stored fault status on the LCD.
 - f. Channel to Phase Association. The conflict monitor channels shall be assigned the same channel numbers as the phase they are monitoring.
- (2) Load Switches. All signal lamp circuits shall be opened and closed by solid state load switches according to NEMA Standards for Traffic Control Systems, TS 2. Load switches shall have a rated load capacity of 15 A minimum within the temperature range of -29 and 165 °F (-34 and 74 °C). A sufficient number of load switches shall be furnished with each controller so the maximum load per circuit will not exceed 900 W. The load switches shall be provided with LED indicator lights to indicate the controller output status.
- (3) Panel and Terminal Facilities. Panel and terminal facilities shall be according to NEMA Standards for Traffic Control Systems, TS 2, except the power to the signal bus shall be provided through a solid state relay(s). Additionally, the panel and terminal facilities shall be according to the following.

The panel board shall be provided on the back wall of the controller cabinet containing local switch sockets and terminal facilities. The load switch sockets shall be positioned so as to accept various NEMA load switches with different sizes of heat sink housings.

The back panel for the cabinet Types IV and V shall contain at a minimum: 12 load switch wired sockets and four flash transfer relay wired sockets. To prevent the conflict monitor from detecting absence of RED voltage on the spare wired sockets, the RED output pin (pin 1) shall be wire jumpered to 120 VAC (pin 3).

One circuit breaker rated 10 A shall be provided for the control equipment and another circuit breaker rated 40 A shall be provided for the signal load.

The field wire terminals shall be located at least 10 in. (250 mm) above the bottom of the controller cabinet.

- (4) Flasher Unit and Flasher Relay. A flasher unit shall be according to NEMA Standards for Traffic Control Systems TS 2, for NEMA Type 3 Flashers, (15 A, dual circuit) and the following.

Each controller shall be provided with one or more jack mounted flasher units and the necessary relays. The flasher and flasher relay shall not operate at more than 85 percent of its rated load.

In conflict monitor triggered flash, all three color signal indications shall flash in red, all signals controlling the same approach of an intersection shall flash simultaneously, and the pedestrian signal faces shall be dark.

Automatic changes from stop-and-go to flashing operation and vice versa shall begin at a predetermined interval according to the MUTCD 2000, Section 4D-12.

It shall be possible to remove the controller and its associated components from the cabinet with the flasher continuing in operation.

1074.04 Uninterruptable Power Supply (UPS).

(a) Operation.

- (1) The UPS shall be line interactive and provide voltage regulation and power conditioning when utilizing utility power.

The UPS shall be sized appropriately for the intersection load. The total system load shall not exceed the manufacturer's specifications.

A standard UPS shall provide a minimum of two hours full run-time operation for LED signal modules load at 77 °F (25 °C) (minimum 700 W/1000 VA active output capacity, with 80 percent minimum inverter efficiency). An extended UPS shall provide a minimum of six hours full run-time operation for the same conditions.

- (2) The maximum transfer time from loss of utility power to switchover to battery backed inverter power shall be 65 milliseconds.
- (3) The UPS shall have four sets of normally open (NO) and normally closed (NC) single-pole double-throw (SPDT) relay contact closures, available on a panel-mounted terminal block, rated at a minimum 120 V/1 A, and labeled so as to identify each contact according to the plans.
 - a. The first set of NO and NC contact closures shall be energized whenever the unit switches to battery power. Contact shall be labeled or marked "On Batt".
 - b. The second set of NO and NC contact closures shall be energized whenever the battery approaches approximately 40 percent of remaining useful capacity. Contact shall be labeled or marked "Low Batt".
 - c. The third set of NO and NC contact closures shall be energized two hours after the unit switches to battery power. Contact shall be labeled or marked "Timer".

- d. The fourth set of NO and NC contact closures shall be energized in the event of inverter/charger failure. Contact shall be labeled or marked "UPS Fail".
- (4) Operating temperature for the inverter/charger, power transfer relay, and manual bypass switch shall be -35 to 165 °F (-37 to +74 °C).
- (5) Both the power transfer relay and manual bypass switch shall be rated at 240 VAC/30 amps, minimum.
- (6) The UPS shall use a temperature-compensated battery charging system. The charging system shall compensate over a range of 1.4 – 2.2 mV/°F (2.5 - 4.0 mV/°C) per cell. The temperature sensor shall be external to the inverter/charger unit. The temperature sensor shall come with 6.5 ft (2 m) of wire.
- (7) Batteries shall not be recharged when battery temperature exceeds 122 °F \pm 5 °F (50 °C \pm 3 °C).
- (8) The UPS shall bypass the utility line power whenever the utility line voltage is outside of the following voltage range: 100 VAC to 130 VAC (\pm 2 VAC).
- (9) When utilizing battery power, the UPS output voltage shall be between 110 and 125 VAC, pure sine wave output, \leq 3 percent THD, 60 Hz \pm 3 Hz.
- (10) The UPS shall be compatible with the Department's traffic controller assemblies utilizing NEMA TS 1 or NEMA TS 2 controllers and cabinet components for full time operation.
- (11) When the utility line power has been restored at above 105 VAC \pm 2 VAC for more than 30 seconds, the UPS shall dropout of battery backup mode and return to utility line mode.
- (12) When the utility line power has been restored at below 125 VAC \pm 2 VAC for more than 30 seconds, the UPS shall dropout of battery backup mode and return to utility line mode.
- (13) The UPS shall be equipped to prevent a malfunction feedback to the cabinet or from feeding back to the utility service.
- (14) In the event of inverter/charger failure, the power transfer relay shall revert to the NC state, where utility line power is reconnected to the cabinet. In the event of an UPS fault condition, the UPS shall always revert back to utility line power.
- (15) Recharge time for the battery, from "protective low-cutoff" to 80 percent or more of full battery charge capacity, shall not exceed twenty hours.

- (16) The manual bypass switch shall be wired to provide power to the UPS when the switch is set to manual bypass.
 - (17) When the intersection is in battery backup mode, the UPS shall bypass all internal cabinet lights, ventilation fans, and service receptacles.
 - (18) As the battery reserve capacity reaches 50 percent, the intersection shall automatically be placed in all-red flash. The UPS shall allow the controller to automatically resume normal operation after the power has been restored. The UPS shall log an alarm in the controller for each time it is activated.
 - (19) A blue LED indicator light shall be mounted on the front of the traffic signal cabinet or on the side of the UPS cabinet facing traffic and shall turn on to indicate when the cabinet power has been disrupted and the UPS is in operation. The light shall be a minimum 1 in. (25 mm) diameter, be viewable from the driving lanes, and able to be seen from 200 ft (60 m) away.
 - (20) All 24 volt and 48 volt systems shall include an external component that monitors battery charging to ensure that every battery in the string is fully charged. The device shall compensate for the effects of adding a new battery to an existing battery system by ensuring that the charge voltage is spread equally across all batteries.
- (b) Mounting/Configuration.
- (1) General.
 - a. The inverter/charger unit shall be rack or shelf-mounted.
 - b. All interconnect wiring provided between the power transfer relay, manual bypass switch, and cabinet terminal service block shall be at least 6.5 ft (2 m) of #10 AWG wire.
 - c. Relay contact wiring provided for each set of NO/NC relay contact closure terminals shall be 6.5 ft (2 m) of #18 AWG wire.
 - d. To ensure interchangeability between all UPS manufacturers, the UPS power transfer relay and manual bypass switch shall be interconnected with Type IV or Type V NEMA cabinets as shown on the plans.
 - (2) Battery Cabinet.
 - a. The inverter/charger and power transfer relay shall be installed inside the external battery cabinet and the manually bypass switch shall be installed inside the traffic signal cabinet.
 - b. Batteries shall be housed in a separate NEMA Standard TS 2 rated Type II cabinet. This external battery cabinet shall be according to Article 1074.03 for the construction and finish of the cabinet.

- c. No more than two batteries shall be mounted on individual shelves for a cabinet housing four batteries and no more than four batteries per shelf for a cabinet housing eight batteries.
 - d. A minimum of three shelves shall be provided. Each shelf shall support a load of 132 lb (60 kg) minimum for dual batteries.
 - e. The battery cabinets housing four batteries shall have nominal outside dimensions according to a NEMA Type II cabinet; or alternatively, a width of 14 in. (355 mm), a depth of 9 in. (230 mm), and a height of 45 to 55 in. (1.14 to 1.4 m). The battery cabinets housing eight batteries shall have nominal outside dimensions according to a NEMA Type III cabinet; or alternatively, a width of 28 in. (710 mm), a depth of 9 in. (230 mm), and a height of 45 to 55 in. (1.14 to 1.4 m). Clearance between shelves shall be a minimum of 10 in. (250 mm).
 - f. The battery cabinet shall be ventilated through the use of louvered vents, filters, and one thermostatically controlled fan as per NEMA TS 2 specifications. The cabinet fan shall not be energized when the traffic signals are on UPS power.
 - g. The battery cabinet shall have a door opening to the entire cabinet. The door shall be attached to the cabinet through the use of a continuous stainless steel or aluminum piano hinge. The cabinet shall be provided with a main door lock which shall operate with a traffic industry conventional No. 2 key. Provisions for padlocking the door shall be provided.
 - h. The UPS with battery cabinet shall come with all bolts, conduits and bushings, gaskets, shelves, and hardware needed for mounting.
 - i. A warning sticker shall be placed on the outside of the cabinet indicating that there is an uninterruptable power supply inside the cabinet.
- (c) Maintenance, Displays, Controls, and Diagnostics.
- (1) The UPS shall include a display and/or meter to indicate current battery charge status and conditions.
 - (2) The UPS shall have lightning surge protection compliant with IEEE/ANSI C.62.41.
 - (3) The UPS shall be equipped with an integral system to prevent battery from destructive discharge and overcharge.
 - (4) The UPS hardware and batteries shall be easily replaced without requiring any special tools or devices.

- (5) The UPS shall include a resettable front-panel event counter display to indicate the number of times the UPS was activated and a front-panel hour meter to display the total number of hours the unit has operated on battery power.
 - (6) The UPS shall be equipped with an RS-232 port.
 - (7) The manufacturer shall include two sets of equipment lists, operation and maintenance manuals, board-level schematic and wiring diagrams of the UPS, and battery data sheets. The manufacturer shall include any software needed to monitor, diagnose, and operate the UPS. The manufacturer shall include any required cables to connect the UPS to a laptop computer.
- (d) Battery System.
- (1) Individual batteries shall be 12 V type, 65 amp-hour minimum capacity at 20 hours, and shall be easily replaced and commercially available off the shelf.
 - (2) Batteries used for the UPS shall consist of four to eight batteries with a cumulative minimum rated capacity of 240 amp-hours.
 - (3) Batteries shall be premium gel cell, deep cycle, completely sealed, prismatic lead-calcium based, silver alloy, valve regulated lead acid (VRLA) requiring no maintenance.
 - (4) Batteries shall be certified by the manufacturer to operate over a temperature range of -13 to 160 °F (-25 to + 71 °C).
 - (5) The batteries shall be provided with appropriate interconnect wiring and corrosion-resistant mounting trays and/or brackets appropriate for the cabinet into which they will be installed.
 - (6) Batteries shall indicate maximum recharge data and recharging cycles.
 - (7) Battery interconnect wiring shall be via a modular harness. Batteries shall be shipped with positive and negative terminals pre-wired with red and black cabling that terminates into a typical power-pole style connector. The harness shall be equipped with mating power-pole style connectors for the batteries and a single, insulated plug-in style connection to the inverter/charger unit. The harness shall allow batteries to be quickly and easily connected in any order and shall be keyed and wired to ensure proper polarity and circuit configuration.
 - (8) Battery terminals shall be covered and insulated so as to prevent accidental shorting.

SECTION 1075. RESERVED

SECTION 1076. WIRE AND CABLE**1076.01 Multi-Conductor Power Cable.**

- (a) General. The cable shall be an assembly of insulated power conductors, plus an insulated ground wire cabled according to UL 854 with fillers and binder tape, and with a jacket overall. The cable shall be rated 194 °F (90 °C) dry and 167 °F (75 °C) wet.

All conductors in the assembly may be either coated, (thinned), or uncoated copper, except all conductors of a given cable type for the project shall be of the same type and be according to Article 1066.02.

- (b) Ground Conductor. The insulated ground conductor shall correspond to the insulated conductor size as indicated in the following table.

Insulated Conductor Size, AWG	Insulated Ground Conductor Size (AWG) Min.
8	10
6	8
4	8
2 thru 2/0	6
3/0 thru 4/0	4

- (c) Insulation. Each conductor shall be insulated with XLP insulation according to Article 1066.03.

Conductor insulation shall be color coded. Neutral conductors shall be color coded white. Three conductor cables (plus ground) for use on single phase systems shall be color coded one black, one red, and one white. Two conductor (plus ground) cables for use on single phase systems shall be color coded one black and one white when used on phase-to-neutral systems, and one black and one red when used on phase-to-phase systems. Three conductor cables for use on three phase systems shall be color coded one black, one red, and one blue. Ground conductors shall be color coded green. Color coding for other cable configurations and systems shall be as directed by the Engineer. Color coding shall be made by means of impregnating the insulation with the color. The coloring process shall impregnate a color which is fade resistant. Color coding via striping, lettering, painting, or other means will not be acceptable for these systems. Each conductor shall be marked by printing in a contrasting color the size, voltage rating, type of insulation, and required UL information.

- (d) Overall Jacket. The cable assembly shall have chlorinated polyethylene (CPE) jacket applied over the assembly. The jacket shall meet the requirements of ICEA S-68-616, Part 4 and the sunlight resistant requirements of UL Standard 854. The jacket shall be marked by means of surface ink printing indicating manufacturer, number of conductors, size, voltage rating, and required UL information.

- (e) **Quality Control.** The cable shall be manufactured and tested according to ICEA S-75-381, NEMA WC 58 and UL 854.

Manufacturer's information submitted for approval shall include product and other data sufficient to verify compliance with all specified requirements. The cable shall be shipped to the site in wood-lagged reels or other equivalent means as approved by the Engineer. Each reel shall be tagged.

1076.02 Fiber Optic Cable. Fiber optic cables shall be as follows.

- (a) **General.** The outside plant, all-dielectric, loose-tube fiber optic cable shall be according to the ANSI, Electronics Industries Association (EIA) and Telecommunications Industries Association (TIA) for the multimode cable of the size specified, and the following.
- (b) **Fiber.** Each fiber shall be multimode, graded index, and a specified nominal diameter (core/clad). Each fiber attenuation shall not exceed 3.5 dB/km nominal, measured at room temperature at 850 nm and the bandwidth shall be a minimum of 160 MHz/km at 850 nm. The fibers and the buffered tubes containing loose fibers shall be color coded according to the following industry standard color coding scheme.

Fiber No./ Tube No.	Color	Fiber No./ Tube No.	Color
1	Blue	7	Red
2	Orange	8	Black
3	Green	9	Yellow
4	Brown	10	Violet
5	Slate	11	Rose
6	White	12	Aqua

- (c) **Cable Construction.**

- (1) **Central Member.** The central member of the cable shall be a glass reinforced plastic rod designed to prevent buckling of the cable.
- (2) **Fillers.** Dielectric fillers may be included in the cable core where needed to lend symmetry to the cable cross-section.
- (3) **Buffer Tube Gel.** Each buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogeneous gel. The gel shall be free from dirt and foreign matter and be readily removable with conventional non toxic solvents.
- (4) **Cable Core Gel.** In addition to the buffer tube gel properties the gel filling the cable core interstices shall be water blocking.
- (5) **Ripcord.** The cable shall contain at least one ripcord under the jacket.
- (6) **Tensile Strength Member.** The cable tensile strength shall be provided by high tensile strength aramid yarns.

- (7) Cable Jacket. The cable shall be sheathed with medium density polyethylene. The polyethylene jacket shall be a consistent thickness having a minimum acceptable average thickness of 0.056 in. (1.4 mm). The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.
- (8) Cable Marking. The cable jacket or sheath shall be marked with the manufacturer's name, the words "Optical Cable", year of manufacture, and with sequential foot (meter) marks.
- (d) Tensile Load. The cable shall withstand a maximum pulling tension of 600 lb (2700 N) during installation, short term and 135 lb (600 N) upon installation, long term.
- (e) Temperature Range. The shipping, storing, installing, and operating range of the cable shall be -22 to 158 °F (-30 to 70 °C).
- (f) Cable Performance Tests. The cable shall be according to the standard Fiber Optic Test Procedure for the following performance measures.
 - Fluid Penetration
 - Compound Drip
 - Compressive Loading Resistance
 - Cyclic Flexing
 - Cyclic Impact
 - Tensile Loading and Bending
- (g) Quality Assurance.
 - (1) Proof Tested. Each optical fiber shall be proof tested by the fiber manufacturer at a minimum stress of 50 kips/sq in. (350,000 kPa).
 - (2) Attenuation Tested. Each optical fiber shall be 100 percent attenuation tested by the cable manufacturer and the attenuation of each fiber shall be provided with each cable reel.
- (h) Packaging.
 - (1) Cable Ends. The top and bottom ends of the cable shall be available for testing. The cable ends shall be sealed to prevent moisture ingress.
 - (2) Cable Label. Each cable reel shall have a durable weatherproof label which shows the actual length of the cable on the reel and the attenuation of each fiber expressed in dB/km.

1076.03 Span Wire and Tether Wire. Span and tether wire shall be as follows.

- (a) Wire. The span wire shall be 3/8 in. (9 mm) nominal diameter, seven strand, zinc-coated steel wire according to ASTM A 475, Utilities Grade or better.

The tether wire shall be 1/4 in. (6 mm) nominal diameter, seven strand, zinc-coated steel wire according to ASTM A 475, High Strength Grade or better.

- (b) Accessories. All accessories, except cable hangers, shall be made of galvanized steel or noncorrosive material. Cable hangers shall be made of exterior black nylon or steel. The tensile strength of all accessories, except cable hangers, shall be equal to or greater than the tensile strength of the wire with which they are used. Thimble-eye bolts shall be 5/8 in. (15 mm) in nominal diameter and be according to ASTM A 307.

1076.04 Electric Cable – Signal, Lead-in, Communication, Service, and Equipment Grounding Conductor.

- (a) Signal Cable. The signal cable shall transmit 120 VAC to signal heads, pedestrian heads and internally illuminated signs, or transmit 24 VDC to pedestrian push-buttons. The signal cable shall be according to IMSA No. 19-1 or IMSA No. 20-1. The tracer color lines shall be extruded with the insulation extrusion. The conductors shall be copper, solid or stranded, and No. 12 or 14 AWG.
- (b) Lead-in Cable Single-Pair. The lead-in cable single-pair shall transmit and receive the vehicle detection signal between the loop detector unit and the detector loop. The lead-in cable single-pair shall be according to IMSA No. 50-2. The conductors shall be stranded tinned copper, and No. 14, 16 or 18 AWG.
- (c) Communication Cable and Lead-in Cable Multipair.
 - (1) Conductors. The fully annealed tinned copper shall be according to ASTM B 33. The stranded conductors shall be according to ASTM B 8 for concentric stranding or ASTM B 174 for bunch stranding. The conductors shall be No. 16 or 18 AWG, 3, 6, 9 or 12 pair.

- (2) Insulation. The polyethylene insulation shall be according to ASTM D 1248, Type 1, Grade 4, Class A or B. The minimum insulation thickness at any point shall not be less than 90 percent of average insulation thickness of 20 mil (0.51 mm).

Conductor Insulation Color Code. All pairs shall have one conductor with black color insulation and one conductor with insulation of another unique non-black color.

- (3) Shielding. The conductors shall be in twisted pairs and each pair shall be individually shielded. The shielding shall be aluminized mylar or polyester. One stranded tinned copper drain wire shall be provided.

The shielding shall be 100 percent effective by providing a metal-to-metal contact between adjacent wraps. The capacitance measured between conductors shall be 30 (100) picofarads or less per foot (meter). The capacitance measured between one conductor and another conductor connected to the shield shall be 55 (180) picofarads or less per foot (meter).

- (4) Jacket. The jacket shall be polyvinyl chloride according to IMSA No. 39-2, or polyethylene according to IMSA No. 40-6.
- (5) Identification. Each shipping length of cable shall show the name of the manufacturer, the year of manufacture, the voltage rating, the UL listing mark, and the conductor size in AWG. This information shall be applied every 2 ft (0.61 m) or less to the outer surface of the jacket by indent printing. The electric cables furnished shall not be dated more than five years prior to the time of installation.
- (6) Sampling, inspection and acceptance. The cable shall be according to IMSA No. 39-2, or IMSA No. 40-6.
- (d) Service Cable. The stranded copper, cross linked polyethylene insulated service cable shall be according to Articles 1066.02 and 1066.03.
- (e) Equipment Grounding Conductor. The cross linked polyethylene (XLP) insulated conductor shall be according to Articles 1066.02 and 1066.03. The stranded copper conductor shall be No. 6 AWG and the insulation color shall be green.

SECTION 1077. POST AND FOUNDATION

1077.01 Traffic Signal Post. The traffic signal post shall be designed to support the traffic signal loading shown on the plans. The design and fabrication shall be according to the Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, as published by AASHTO.

- (a) Post. The post shall be made of steel or aluminum and have an outside diameter of 4 1/2 in. (115 mm). The post shall be threaded for assembly to the base. Aluminum posts shall be according to the specifications for Schedule 80 aluminum pipe. Steel posts shall be according to the specifications for Schedule 40 steel pipe.
- (b) Base. The base of a steel post shall be cast iron. The base of an aluminum post shall be aluminum. The base shall be threaded for the attachment to the threaded post. The base shall be approximately 15 in. (375 mm) high and 13 1/2 in. (335 mm) square at the bottom. The bottom of the base shall be designed to accept four 5/8 in. (16 mm) diameter anchor rods evenly spaced in a 12 1/2 to 13 in. (320 to 330 mm) diameter circle. The base shall be true to pattern, with sharp clean cutting ornamentation, and equipped with access doors for cable handling. The door shall be fastened to the base with stainless steel screws. A grounding lug shall be provided inside the base.

The aluminum post and base shall be drilled at the third points around the diameter and 1/4 in. by 2 in. (6 mm by 50 mm) stainless steel bolts shall be inserted to prevent the post from turning and wobbling.

- (c) Anchor Rods. The anchor rods shall be a minimum of 5/8 in. (16 mm) in diameter and 16 in. (400 mm) long and shall be according to Article 1006.09. The anchor rods shall be threaded approximately 3 in. (75 mm) at one end and have a bend at the other end. The first 5 in. (125 mm) at the threaded end shall be galvanized. One each galvanized nut and washer shall be furnished with each anchor rod.
- (d) Finish. The steel post and the cast iron base shall be either hot dipped galvanized according to AASHTO M 111 or shop painted with one coat of primer and two coats of yellow enamel according to Section 851. If the post and the base are threaded after the galvanization, the bare exposed metal shall be immediately cleaned to remove all cutting solvents and oils, and then spray painted with two coats of an approved galvanized paint.

1077.02 Pedestrian Push-Button Post. Pedestrian push-button posts shall be as follows.

- (a) Post. The steel post shall be according to Article 1077.01, except the nominal size shall be 3 in. (75 mm). The Type I pedestrian push button post shall use a 3 in. (75 mm) threaded connection. The Type II pedestrian push-button post shall include two flange plates located approximately 1 in. (25 mm) above the ground level.
- (b) Finish. The post and cap shall be either hot dipped galvanized according to AASHTO M 111 or shop painted with one coat of primer and two coats of yellow enamel according to Section 851. If the post is threaded after galvanization, the bare exposed metal shall be immediately cleaned to remove all cutting solvents and oils, and then spray painted with two coats of an approved galvanized paint.

1077.03 Mast Arm Assembly and Pole. Mast arm assembly and pole shall be as follows.

- (a) Steel Mast Arm Assembly and Pole and Steel Combination Mast Arm Assembly and Pole. The steel mast arm assembly and pole and steel combination mast arm assembly and pole shall consist of a traffic signal mast arm, a luminaire mast arm or davit (for combination pole only), a pole, and a base, together with anchor rods and other appurtenances. The configuration of the mast arm assembly, pole, and base shall be according to the details shown on the plans.
- (1) Loading. The mast arm assembly and pole, and combination mast arm assembly and pole shall be designed for the loading shown on the Highway Standards or elsewhere on the plans, whichever is greater. The design shall be according to AASHTO "Standard Specification for Structural Supports for Highway Signs, Luminaries and Traffic Signals" 1994 Edition for 80 mph (130 km/hr) wind velocity. However, the arm-to-pole connection for tapered signal and luminaire arms shall be according to the "ring plate" detail as shown in Figure 11-1(f) of the 2002 Interim, to the AASHTO "Standard Specification for Structural Supports for Highway Signs, Luminaries and Traffic Signals" 2001 4th Edition.

- (2) **Structural Steel Grade.** The mast arm and pole shall be fabricated according to ASTM A 595, Grade A or B; ASTM A 572, Grade 55; or ASTM A 1011, Grade 55 HSLAS Class 2. The base and flange plates shall be of structural steel according to AASHTO M 270, Grade 50 (M 270M, Grade 345). Luminaire arms and trussed arms 15 ft (4.5 m) or less shall be fabricated from one steel pipe or tube size according to ASTM A 53, Grade B or ASTM A 500, Grade B or C. All mast arm assemblies, poles, and bases shall be galvanized according to AASHTO M 111.
- (3) **Fabrication.** The design and fabrication of the mast arm assembly, pole, and base shall be according to the requirements of the Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals published by AASHTO. The mast arm and pole may be of single length or sectional design. If section design is used, the overlap shall be at least 150 percent of the maximum diameter of the overlapping section and shall be assembled in the factory.

The manufacturer will be allowed to slot the base plate in which other bolt circles may fit, providing that these slots do not offset the integrity of the pole. Circumferential welds of tapered arms and poles to base plates shall be full penetration welds.

- (4) **Shop Drawing Approval.** The Contractor shall submit detailed shop drawings showing design materials, thickness of sections, weld sizes, and anchor rods to the Engineer for approval prior to fabrication. These drawings shall be at least 11 x 17 in. (275 x 425 mm) in size and of adequate quality for microfilming.

- (b) **Anchor Rods.** Anchor rods shall be according to Article 1006.09, Grade 105, and shall be threaded a minimum of 7 1/2 in. (185 mm) at one end and have a bend at the other end. At a minimum, the first 12 in. (300 mm) at the threaded end shall be galvanized. Two nuts, one lock washer, and one flat washer shall be furnished with each anchor rod.

1077.04 Traffic Signal Wood Pole.

- (a) **Pole.** Wood pole shall be full treated southern pine, Douglas fir, or western red cedar according to the American National Standard Specifications and Dimensions for Wood Poles. The preservative treatment shall be according to the American Wood Preservers' Association Standard T1.
- (b) **Down Guy.** The down guy shall consist of a guy wire and other appurtenances as shown on the plans. The guy wire shall be of 3/8 in. (9.5 mm) nominal diameter seven strand, zinc-coated steel wire according to ASTM A 475, Utilities Grade or better. The other appurtenances shall be galvanized according to AASHTO M 232 and be according to the following.

The anchor shall have a minimum expanded area of 125 sq in. (81,000 sq mm).

The anchor rod shall have a nominal diameter of 5/8 in. (16 mm) and a minimum breaking strength of 11,500 lb (51,200 N).

The guy guard shall be 7 ft (2.1 m) long, tapered, and made of 18 gauge steel minimum, except for sidewalk guys, the guy guards shall be made of heavy-duty plastic.

The guy wire clamps shall be three bolt and have a minimum breaking strength of 11,500 lb (51,200 N).

The dead-ends shall be made of the same material as the guy wire.

SECTION 1078. LIGHT EMITTING DIODE (LED) TRAFFIC SIGNAL HEAD

1078.01 Light Emitting Diode (LED) Signal Head and Optically Programmed LED Signal Head.

- (a) Face. The signal face shall be of sectional design and expandable.
- (b) Housing and Door. The polycarbonate housing or door shall be made of Ultra-Violet stabilized polycarbonate resin and shall be molded in one piece with a minimum thickness of 0.09 in. (2.25 mm).

The top and bottom of each housing shall have an opening to accommodate standard 1.5 in. (38 mm) pipe fittings and brackets. The top and bottom openings shall each have an interlocking ring integral with the signal section. The locking ring shall have 72 teeth, permitting rotation of the signal section in five degree steps.

The door shall be securely attached to the housing with stainless steel hardware. All access openings shall be provided with neoprene or rubber gaskets.

Each signal section shall attach to each adjoining section in the signal head with sufficient strength to prevent separation or movement between the sections.

- (c) Optical Unit.

(1) The LED signal section shall be according to the following.

- a. General Requirements. The LED signal head shall fully comply with the Institute of Transportation Engineers (ITE) LED purchase specification, "Vehicle Traffic Control Signal Heads: LED Circular Signal Supplement", and "Vehicle Traffic Control Signal Heads: LED Vehicle Arrow Traffic Signal Supplement", in effect on the date of invitation for bids, except as modified herein.
- b. Physical and Mechanical Requirements. The power supply for the LED module shall be integrated with the unit.

- c. Photometric Requirements. The illuminated portion of the arrow module shall be uniformly and completely dispersed with the LEDs.
- d. Electrical Requirements. The maximum and nominal wattage requirements for 12 in. (300 mm) circular and arrow modules shall be as follows.

Module Type	Maximum Watts (W) at 165 °F (74 °C)	Nominal Watts (W) at 77 °F (25 °C)
12 in. (300 mm) Yellow Circular	25	22
12 in. (300 mm) Yellow Arrow	12	10
12 in. (300 mm) Green Circular	15	15
12 in. (300 mm) Green Arrow	11	11
12 in. (300 mm) Red Circular	17	11
12 in. (300 mm) Red Arrow	12	9

The individual LEDs shall be wired such that failure of a single LED shall result in loss of light from only that LED.

- (2) The optically programmed LED signal section shall be according to the following.
 - a. LED Lamp Module. The LED lamp module shall be designed and constructed to be installed in a programmed visibility signal housing without modifications to the housing. The chromaticity of the module shall comply with the ITE VTCSH-STD Part 2 specifications.

The nominal wattage requirements for 12 in. (300 mm) circular modules shall be as follows.

Module Type	Nominal Watts (W) at 77 °F (25 °C)
12 in. (300 mm) Yellow Circular	17
12 in. (300 mm) Green Circular	14
12 in. (300 mm) Red Circular	10

The individual LEDs shall be wired such that failure of a single LED shall result in loss of light from only that LED.

- b. Optical Limiter-Diffuser. The optical limiter-diffuser shall provide an imaging surface at focus on the optical axis for objects 900 to

1,200 ft (275 to 365 m) distance and permit an optical masking tape to be variously applied as determined by the desired visibility zone. The optical limiter diffuser shall be provided with positive indexing means and composed of heat-resistant glass.

- c. Objective Lens. The objective lens shall be a high resolution planar incremental lens hermetically sealed with a flat laminate of weather-resistant acrylic. The lens shall be symmetrical in outline and capable of being rotated to any 90 degree orientation about the optical axis. The projected signal indication shall be capable of being veiled anywhere within 15 degrees of the optical axis. The indication shall not result from external illumination and shall be according to the ITE Standards.
- d. Photo Control. The photo control shall comprise an integrated, directional light sensing and regulating device interposed between lamp and line wires. The lamp intensity shall not be less than 37 percent of uncontrolled intensity at 1,000 foot candle (10,000 lux) and shall be reduced to 15 ± 2 percent of maximum at less than 1 foot candle (10 lux). The response shall be proportional and essentially instantaneous to any detectable increase of illumination from darkness to 1,000 foot candle (10,000 lux) and damped for any increase from 1,000 foot candle (10,000 lux). The photo control shall be compatible with 60 Hz input and responsive within the range of 105 to 135 VAC.
- (d) Terminal Block. Each signal face shall contain a terminal block with at least ten terminals.
- (e) Visor. The conventional signal section shall be furnished with a tunnel type visor, and the optically programmed signal section shall be furnished with a cutaway type visor. The visor shall be a minimum of 0.05 in. (1.2 mm) in thickness. The visor for a 12 in. (300 mm) signal section shall be a minimum of 9 in. (225 mm) in length.
- (f) Mounting Bracket. The mounting bracket shall be made of steel or aluminum. Signal heads with more than one signal face shall be furnished with terminal compartments. Each terminal compartment shall contain a terminal block with at least 16 terminals.
- (g) Finish. The aluminum signal head shall be painted according to Section 851, except the primer shall be applied to all areas. For polycarbonate signal heads, the colors specified in Section 851 shall be an integral part of the material composition.

1078.02 Light Emitting Diode (LED) Pedestrian Signal Head. The pedestrian signal head shall be according to the MUTCD and the ITE Standards current at the time the project is advertised.

- (a) Housing and Door. The housing and door of each section shall be according to Article 1078.01(b).

- (b) Optical Unit. Only symbolic walk (walking person), don't walk (upraised palm), and number indications shall be used. The pedestrian signal heads shall be according to the ITE publication, "Pedestrian Traffic Control Signal Indications", in effect on the date of invitation for bids, except as modified herein. The nominal message bearing surface of pedestrian signal heads shall be 12 in. x 12 in. (300 mm x 300 mm) or 16 in. x 18 in. (400 mm x 450 mm). The minimum height of the symbols and numbers displayed shall be 9 in. (225 mm).

The LED signal heads shall also meet the following requirements.

- (1) Physical and Mechanical Requirements. The power supply for the LED module shall be integrated with the unit.
- (2) Photometric Requirements. The illuminated portion of the module shall be uniformly and completely dispersed with the LEDs.
- (3) Electrical Requirements. The nominal power consumption by the countdown pedestrian signal head shall be 20 watts or less.

The individual LEDs shall be wired such that failure of a single LED shall result in loss of light from only that LED.

- (c) Terminal Block. Each pedestrian signal face shall contain a terminal block with at least eight terminals.
- (d) Visor. The visor for each signal shall be either the tunnel visor or the low profile visor. The tunnel visor shall be according to Article 1078.01(e).

The low profile visor shall be no deeper than 2 in. (50 mm) and shall consist of louvers to provide shade from the direct sun rays and a cutoff angle restricting the unintended viewing of the signal indication. The low profile visor shall be impregnated black polycarbonate, eliminating the deterioration of the color and texture of the visor from the exposure to the ultraviolet sun rays.

- (e) Mounting Bracket. The mounting bracket shall be according to Article 1078.01(f), except no terminal compartment will be required.
- (f) Finish. The aluminum pedestrian signal heads shall be according to Section 851, except the primer shall be applied to all areas. For polycarbonate pedestrian signal heads, the colors specified in Section 851 shall be an integral part of the material composition.

1078.03 Traffic Signal Backplate. The traffic signal backplate shall be made of sheet aluminum, sheet ABS plastic, or ABS plastic (vacuum formed). The sheet aluminum shall have a nominal thickness of 0.05 in. (1.3 mm) and shall be according to ASTM B 209, Alloy 3003-H14 or better. The sheet ABS plastic shall have a nominal thickness of 0.1 in. (2.5 mm) and shall have a minimum tensile strength of 4,300 psi at 73 °F (30,000 kPa at 23 °C). The vacuum formed ABS plastic backplate shall have a nominal thickness of 1/8 in. (3 mm), a nominal 1/2 in. (13 mm) deep back

flange on all inside and outside edges, and a minimum tensile strength of 4,300 psi at 73 °F (30,000 kPa at 23 °C).

The backplates shall be composed of one piece. The backplate shall be designed to be attached to a signal face without interfering with the opening and closing of the traffic signal door. It shall be rectangular in shape with round corners and shall be of such dimensions as to give an exposed margin of 5 in. (125 mm) on each side.

The surface of the louvered backplate shall provide openings (louvers) to allow wind to penetrate and reduce wind loading. The louver openings shall cover a minimum of 20 percent of the surface area of the backplate.

The reflective backplate shall have a 3 in. (75 mm) wide fluorescent yellow retroreflective strip applied to the outside perimeter of the face of the backplate. When retroreflective sheeting is specified, the sheeting shall be Type AZ sheeting according to Article 1091.03 and applied in the preferred orientation for the maximum angularity according to the manufacturer's recommendations.

The aluminum backplates shall be shop painted with one coat of primer and two coats of dull (matte) black enamel. The painting shall be according to Section 851. For the plastic backplates, the black color shall be an integral part of the material composition and shall not deteriorate under the exposure to ultraviolet sun rays.

1078.04 Directional Louver. The directional louver shall be made of aluminum alloy and shall have a minimum of five vanes. The directional louver shall be shop painted with one coat of primer and two coats of dull (matte) black enamel. The painting and materials shall be according to Section 851.

SECTION 1079. DETECTOR LOOP

1079.01 Inductive Loop Detector. The inductive loop detector shall be according to the NEMA Standards for Traffic Control Systems, TS 2 and the following.

(a) Functions.

The inductive loop detector shall have a minimum of seven levels of sensitivity control and shall be of sufficient sensitivity to detect the smallest licensable motor vehicle, including motorbikes.

The inductive loop detector shall have a minimum of two modes of operation, presence or pulse.

The inductive loop detector shall be capable of self tuning.

The inductive loop detector shall, in a failure condition, register a continuous call to the signal controller.

Extend Call – Delay Call. The inductive loop detector shall change from delay mode to extend mode and vice versa at the end of the time set for

each mode. The inductive loop detector shall have a means of visually indicating the timings of delay and extension settings are in effect.

(b) Special Feature.

System Output. In addition to supplying normal timing output, the detector shall be capable of providing a simultaneous system output for traffic volume, occupancy, and speed measuring. The system output shall be constant and not affected by delay or extension timings. This output shall allow either presence or pulse operation which may be selectable from a front panel switch. The presence and pulse outputs shall be according to NEMA. When required, this feature shall be internal to the detector.

1079.02 Detector Loop and Sealer.

(a) Wire. Detector loop wire is classified into three types as follows.

- (1) Type I detector loop wire and the loose encasing shall be according to IMSA 51-5.
- (2) Type II detector loop wire shall be No. 16 AWG, mineral-insulated, copper sheathed cable. The conductor shall be insulated with magnesium oxide and enclosed in a seamless copper sheath with a polyethylene jacket. A terminal subassembly kit composed of a pot, cap, sealer, and sleeves shall be supplied with the cable.
- (3) Type III detector loop wire shall be No. 14 or 16 AWG, Type THWN, THHN, or XHHW, with stranded copper conductor.

(b) Preformed Detector Loop. The preformed detector loop shall be either of the following.

- (1) Rigid Plastic Conduit. The rigid plastic conduit shall be 5/8 in. (16 mm) outer diameter schedule 80 PVC or polypropylene conduit. All bends shall be a 6 in. (150 mm) radius minimum and shall be integral to the conduit.
- (2) Heavy Duty Reinforced Rubber Hose Conduit. The heavy duty reinforced rubber hose conduit shall be Class A oil resistant, hydraulic-type rubber hose reinforced with synthetic cord. It shall have an inner diameter of 3/8 in. (9.5 mm) and an internal pressure rating of 250 psi (1,720 kPa). The loop shall be preformed with a sealed tee connection, and shall be part of one continuous piece with initial lead-in connection wires. No joints or splices shall be made in the loop or wire, except for their connection to the lead-in wires located outside of the pavement.

(c) Sealer. The Sealer for Type I detector loop shall be one of the following.

- (1) Polyurethane or Two-Component Polyurethane Modified Asphalt. The material shall be cured to be rubber like, and suitable for sealing detector loops in both hot-mix asphalt (HMA) and concrete pavements.

The cured material shall be highly resistant to oil, gasoline, salts, acids, and alkalis.

- (2) Two Component Epoxy or Two Component Polyester Resin. The material shall be cured to be flexible, and suitable for sealing detector loops in both HMA and concrete pavements. The cured material shall be highly resistant to oil, gasoline, salts, acids, and alkalis.

The above material shall have the following properties.

Pot life at 77 °F (25 °C)	13 minutes minimum
Cure Time	4 hours maximum
Shore D Hardness	28 minimum

OTHER ITEMS

SECTION 1080. FABRIC MATERIALS

1080.01 Fabric Envelope for Pipe Underdrains. The fabric envelope for encasing pipe underdrains may be either a knitted, woven, or nonwoven fabric.

- (a) Fabric Materials. Fabric materials shall be as follows.
- (1) Knitted Fabric. Knitted fabric envelope shall be an approved continuous one piece knitted polyester material that fits over the pipe underdrain like a sleeve. It shall be knitted of continuous 150 denier polyester yarn and shall be free from any chemical treatment or coating that might significantly reduce porosity and permeability.
 - (2) Woven or Nonwoven Fabric. The filaments for woven or nonwoven fabric shall be polypropylene, polyester, or polyethylene. The filaments shall be dimensionally stable (i.e., filaments must maintain their relative position with respect to each other) and resistant to delamination. The filaments shall be free from any chemical treatment or coating that might significantly reduce porosity and permeability. Nonwoven fabric shall be needle punched.
 - (3) Physical Properties. The physical properties for both knitted and woven or nonwoven fabric shall be according to the following.

PHYSICAL PROPERTIES				
	Knitted ^{1/}		Woven or Nonwoven	
Min. Weight (oz/sq yd)	3.5 applied 4.8 relaxed	ASTM D 3887 ASTM D 3887	3.5	ASTM D 3776
Min. Wet Grab Tensile Strength (lb)	--	--	100	ASTM D 4632 ^{2/}
Grab Elongation @ Break (%)	--	--	20 min.	ASTM D 4632 ^{2/}
Apparent Opening Size (AOS No.)	30 max.	ASTM D 4751 ^{3/}	30 max. nonwoven ^{3/} 50 max. woven ^{3/}	--
Static Puncture Strength (psi)	116 min.	ASTM D 6241 ^{3/}	--	--

PHYSICAL PROPERTIES (Metric)				
	Knitted ^{1/}		Woven or Nonwoven	
Min. Weight (g/sq m)	119 applied 163 relaxed	ASTM D 3887 ASTM D 3887	120	ASTM D 3776
Min. Wet Grab Tensile Strength (N)	--	--	450	ASTM D 4632 ^{2/}
Grab Elongation @ Break (%)	--	--	20 min.	ASTM D 4632 ^{2/}
Apparent Opening Size (AOS No.)	600 µm max.	ASTM D 4751 ^{3/}	600 µm max. nonwoven ^{3/} 300 µm max. woven ^{3/}	--
Static Puncture Strength (kPa)	890 min.	ASTM D 6241 ^{3/}	--	--

1/ Knitted fabric shall be Type A according to ASTM D 6707.

2/ For woven fabric, test results shall be referenced to orientation with warp or fill, whichever the case may be.

3/ Manufacturer's certification to meet test requirements.

- (b) Handling and Storage. The knitted fabric envelope shall be applied to the pipe underdrain in the shop so as to maintain a uniform applied weight. Woven and nonwoven fabric or underdrains with knitted fabric envelope shall be delivered to the job site in such manner as to facilitate handling and incorporation into the work without damage. Fabric envelope materials shall be stored in ultraviolet-resistant bags until just prior to installation. In no case shall the fabric be stored or exposed to direct sunlight that might significantly diminish its strength or toughness. Torn or punctured fabric envelope shall not be used.

1080.02 Geotextile Fabric. The fabric for silt filter fence shall be a woven fabric meeting the requirements of AASHTO M 288 for unsupported silt fence with less than 50 percent geotextile elongation.

The fabric for ground stabilization shall consist of woven or nonwoven filaments of polypropylene, polyester, or polyethylene. Nonwoven fabric may be needle punched,

heat-bonded, resin-bonded, or combination thereof. The fabric shall be resistant to ultraviolet radiation and be according to the following.

Physical Properties	Ground Stabilization
Grab Tensile Strength (lb) ASTM D 4632 ^{1/}	200 min.
Grab Elongation @ Break (%) ASTM D 4632 ^{1/}	12 min.
Burst Strength (psi) - ASTM D 3786 ^{2/}	250 min.
Trapezoidal Tear Strength (lb) ASTM D 4533 ^{2/}	75
Weight (oz/sq yd) – ASTM D 3776	4.0 min.

Physical Properties (Metric)	Ground Stabilization
Grab Tensile Strength (N) ASTM D 4632 ^{1/}	900 min.
Grab Elongation @ Break (%) ASTM D 4632 ^{1/}	12 min.
Burst Strength (kPa) – ASTM D 3786 ^{2/}	1720 min.
Trapezoidal Tear Strength (N) ASTM D 4533 ^{2/}	335
Weight (g/sq m) – ASTM D 3776	135 min.

- 1/ For woven fabric, test results shall be referenced to orientation with warp or weave, whichever the case may be. Both woven and nonwoven fabric shall be tested wet.
- 2/ Test results may be obtained by manufacturer's certification.

1080.03 Filter Fabric. The filter fabric material shall consist of nonwoven filaments formed from a plastic yarn of a long chain synthetic polymer composed of at least 85 percent by weight of polyolefins, or polyesters, and shall contain stabilizers and/or inhibitors added to the base plastic to make the filaments resistant to deterioration due to ultraviolet and heat exposure. After forming, the fabric shall be processed so that the filaments retain their relative positions with respect to each other. The fabric shall be free of defects or flaws which significantly affect its physical and/or filtering properties.

The filter fabric shall be formed in widths of not less than 6 ft (2 m). Sheets of fabric may be sewn together with thread of a material meeting the chemical requirements given for the plastic yarn to form fabric widths as required. The sheets of filter fabric shall be sewn together at the point of manufacture or another approved location.

The texture of the fabric shall be such that the bedding and riprap will remain in an equilibrium state and not slip or slide. The filter fabric shall have a high dimensional stability when set, have good soil filtration characteristics, have a high resistance to tear propagation in all directions, and be according to the following.

Physical Properties	Gradation 4 & 5	Gradation 6 & 7
Weight of Fabric (oz/sq yd), ASTM D 3776 (Mod.)	6.0	8.0
Burst Strength (psi), ASTM D 3786 ^{1/}	250	300
Trapezoidal Tear Strength (lb), ASTM D 5733 ^{2/}	60	75
Grab Tensile Strength (lb), ASTM D 4632 ^{2/}	160	200
Grab Tensile Elongation (%), ASTM D 4632 ^{2/}	20	20

Physical Properties (Metric)	Gradation 4 & 5	Gradation 6 & 7
Weight of Fabric (g/sq m), ASTM D 3776 (Mod.)	200	270
Burst Strength (kPa), ASTM D 3786 ^{1/}	1720	2070
Trapezoidal Tear Strength (N), ASTM D 5733 ^{2/}	265	335
Grab Tensile Strength (N), ASTM D 4632 ^{2/}	700	900
Grab Tensile Elongation (%), ASTM D 4632 ^{2/}	20	20

1/ Manufacturer's certification of fabric to meet requirements.

2/ Test sample shall be tested wet.

The vendor shall furnish certified test reports with each shipment of material attesting that the fabric meets the above requirements.

A sample of 5 sq yd (4.0 sq m) of the fabric shall be furnished from each shipment for verification testing.

The fabric shall meet the requirements noted in the following and provide an apparent opening size (AOS) determined by the Engineer after an on site investigation of the soil to be protected, based on the following criteria.

(a) Piping Resistance. (soil retention) (Note 1)

(1) Soil with 50 percent or less particles by weight (mass) passing U.S. No. 200 (75 µm) Sieve. AOS less than 0.6 mm (greater than No. 30 (600 µm) Sieve) TF25 Method 6.

(2) Soil with more than 50 percent particles by weight (mass) passing U.S. No. 200 (75 µm) Sieve. AOS less than 0.3 mm (greater than No. 50 (300 µm) Sieve) TF25 Method 6.

(b) Permeability. (cm/sec)(Note 1). K of fabric greater than 10 K of soil – ASTM D 4491.

Note 1. Certification from the manufacturer of fabric is required stating that the product meets the piping resistance and permeability requirements.

1080.04 Fabric Formed Concrete Revetment Mats. Fabric forming material shall consist of specially woven, double layer, open selvage fabric joined in mat configuration. The fabric shall consist of uncoated synthetic yarns with sufficient grab tensile strength and porosity to withstand the pressure of the grout injection pump

without breaking the layers of fabric. Each fabric layer shall exhibit minimum grab tensile strength of 200 lb (900 N) in both warp and fill directions when tested according to ASTM D 4632, Grab Tests, Method 16, using a 4 x 8 in. (100 x 200 mm) sample, 3 in. (75 mm) gage length, clamped in a 1 in. (25 mm) wide by 2 in. (50 mm) long grip, tested at a strain rate of 12 in./min (300 mm/min) in a CRE testing machine. The average of five tests in each direction shall meet the minimum value given above. The fabric shall be tested wet.

Hydrostatic uplift pressure relief shall be provided by installing 1 1/2 in. (40 mm) diameter sewn filter points woven in such a manner as to permit passage of water through the filter points spaced approximately at 8 in. (200 mm) centers for the filter point style mat with average thickness of 3.5 in. (90 mm), and at 8 ft (2.4 m) centers for the uniform cross section style mat with average thickness of 4 in. (100 mm). All filter points shall be checked and cleaned for free passage of water through the filter points after the mat has been pumped and the grout has set. When uniform cross section style mat is specified, the Contractor shall have the option of substituting filter point style mat.

1080.05 Geotechnical Fabric for French Drains. Geotechnical fabric for french drains shall consist of woven or nonwoven filaments of polypropylene, polyester, or polyethylene. Nonwoven fabric may be needle punched, heat-bonded, resin-bonded or combinations thereof. The filaments shall be dimensionally stable (i.e., filaments shall maintain their relative position with respect to each other) and resistant to delamination. The filaments shall be free from any chemical treatment or coating that might significantly reduce porosity and permeability.

The fabric shall be according to the following.

PHYSICAL PROPERTIES	
Weight (oz/sq yd) - ASTM D 3776	3.5 min.
Grab Tensile Strength (lb) - ASTM D 4632 ^{1/}	100 min.
Grab Elongation @ Break (%) - ASTM D 4632 ^{1/}	20 min.
Apparent Opening Size (AOS No.) - ASTM D 4751 ^{2/}	30 max. (nonwoven) 50 max. (woven)

PHYSICAL PROPERTIES (METRIC)	
Weight (g/sq m) - ASTM D 3776	120 min.
Grab Tensile Strength (N) - ASTM D 4632 ^{1/}	450 min.
Grab Elongation @ Break (%) - ASTM D 4632 ^{1/}	20 min.
Apparent Opening Size (AOS No.) - ASTM D 4751 ^{2/}	600 µm max. (nonwoven) 300 µm max. (woven)

1/ For woven fabric, test results shall be referenced to orientation with warp or fill, whichever the case may be. Both woven and nonwoven fabrics shall be tested wet.

2/ Manufacturer's certification of fabric to meet requirements.

SECTION 1081. MATERIALS FOR PLANTING

1081.01 Trees, Shrubs, Vines, and Seedlings. Trees, shrubs, vines, and seedlings shall be according to the current standards adopted by the ANLA.

(a) Quality of Plant Material.

- (1) Plants shall be first class nursery grown representatives of their normal species and varieties. They shall have average or normal well developed branches, together with vigorous root systems. Plants shall be free from insects, diseases, sun scald, knots, stubs, or other objectionable disfigurements. Thin, weak plants will not be accepted.
- (2) Trees shall be free of branches (undertrimmed) no higher from the ground line than 1/2 the total height of the tree; shall have single leaders, be well branched, and with reasonably straight stems. This requirement shall cover general species, but some varieties, which have other characteristics of growth, will be accepted.
- (3) Plants shall be true to their name as specified; however, substitution of plant material of equal quality, type, and size to that specified may be approved by the Engineer if acceptable material of the variety specified is not available. Permission shall be given only after a written request and proposal for substitution is received from the Contractor at least 30 days prior to the proposed planting date.
- (4) Wherever the word "specimen" is used, it shall denote trees which are symmetrical, exceptionally heavy, and full branched. When more than one is required, all shall be uniform in size and shape.
- (5) The southernmost limits for the source of plant material shall be one sub-zone south of the site of the work. The current publication of Plant Hardiness Zones from the USDA's Agricultural Research Service shall be used to designate plant hardiness zones.

(b) Measurement for Size.

- (1) Root System. The root system of all plants shall be sufficient to ensure plant growth.
 - a. Bareroot Trees. All bareroot trees shall have a heavy fibrous root system that has been developed by proper cultural treatment, transplanting, and root pruning.
 - b. Bareroot Shrubs. All bareroot shrubs shall have a well-branched fibrous root system.
- (2) Container Grown Plants. Container grown plants shall be well rooted and established in the container in which they are growing. They shall have grown in the container for a sufficient length of time for the root

system to hold the earth when taken from the container, but not long enough to become pot bound.

- (3) Balled and Burlapped Plants. Plants marked "B&B" are to be balled and burlapped.

(c) Inspection of Plant Material.

- (1) Inspection of plant material will be made at the nursery by the Engineer, or a duly authorized representative, whenever such an examination is deemed practical, and shall be in the field (or in storage houses) of the nursery supplying the material. The Department reserves the right to place identification seals on any or all plants selected.
- (2) Approval of material on such an examination shall not be as construed as an acceptance of it. Final acceptance will not be made until the plant material is in a healthy, growing condition as provided in Article 253.14.
- (3) With respect to inspection for plant diseases and insect infestation, an inspection certificate shall accompany each shipment and on arrival the certificate shall be filed with the Engineer.

(d) Shipment.

- (1) Each species or variety shall be handled and packed in the manner approved for that plant, having regard for the soil and climatic conditions at the time and place of digging and of delivery, and to the time that will be consumed while in transit or delivery. All precautions that are customary in good trade practice shall be taken to ensure the arrival of the plants in good condition.
- (2) Plants shall be packed or covered in such a manner as to ensure adequate protection against damage while in transit. The roots of bare root plants shall be carefully protected with wet straw or other suitable material to ensure the arrival of the plants at destination with the roots in a moist condition.
- (3) When shipment is made by an enclosed vehicle, the vehicle shall be adequately ventilated to prevent any "heating" in transit.
- (4) Unless requested by the Engineer, only a representative amount of shrubs, seedlings, or liners need to be tagged. All other stock furnished shall be legibly tagged with the name or the corresponding key designation as indicated on the plans.

1081.02 Perennial Plants. Perennial plants shall be as follows.

- (a) Bulb Type. Bulb type plants shall include bulbs, tubers, rhizomes, and corms. Bulb type plants shall meet the current ANLA standards. The Contractor shall furnish the Engineer a shipping ticket or label documenting that the variety, color, and size of the bulb type plants supplied are as specified in the plans.

- (b) Ornamental Type, Prairie Type, Wetland Emergent Type, Sedge Meadow Type, and Woodland Type. These plants shall meet the current ANLA standards. Flats or lots of plants shall be clearly labeled by variety, and the Contractor shall furnish the Engineer a shipping ticket or label documenting that the plants supplied are of the variety specified in the plans.

1081.03 Sod. Each piece of sod shall be well covered with turf grass, shall be free from noxious weeds and other objectionable plants, and shall not contain substances injurious to growth. The grass shall be cut to a length of not less than 1 1/2 in. (40 mm) nor more than 4 in. (100 mm) before the sod is cut. The sod shall be cut in rectangular pieces with its shortest side not less than 12 in. (300 mm). The sod shall not be cut less than 1 in. (25 mm) thick. This thickness measurement does not include grass.

With respect to inspection for plant diseases and insect infestation, an inspection certificate shall accompany each shipment and on arrival shall be filed with the Engineer.

- (a) Native Sod. The sod used shall be approved grass that is native to the locality of work. It shall be either nursery grown or field grown and be well rooted and approved by the Engineer prior to being cut and again before it is laid. Sod that has been grown on soil high in organic matter such as peat will not be acceptable. The consistency of adherent soil shall be such that it will not break, crumble or tear during handling and placing of the sod.
- (b) Salt Tolerant Sod.

Variety	Percent by Weight (Mass)
Buffalo Grass Buchloe dactyloides	30 %
Inferno Tall Fescue	20 %
Audubon Red Fescue	15 %
Rescue 911 Hard Fescue	15 %
Rugby Kentucky Bluegrass	5 %
Fults Pucinnellia Distans	15 %

1081.04 Seeds.

- (a) Sampling and Testing. Each lot of seed furnished shall be tested by a State Agriculture Department (including other States) or by land grant college or university agricultural sections or by a Registered Seed Technologist. Germination testing of seed shall be accomplished within the 12 months prior to the seed being installed on the project.

Acceptance of seeds furnished will be based on receipt and approval of a certification covering tests from each lot of seed. Certification shall consist of test reports showing the required test results of lots corresponding to the shipment and signed by the responsible personnel of the testing agency. A

Registered Seed Technologist shall verify his/her signature with his/her Society of Commercial Technologists' seal.

Seeds may be sampled at destination on a random basis and tested for comparison with certification and compliance with these requirements. If deviations are found, the results will be reviewed to determine if the material is acceptable for use. Major deviations may result in a requirement that each lot of material from the source in question be sampled, tested, and approved by the State Agriculture Department before further use.

- (b) **Packing and Storage.** Seeds shall be packed for delivery in suitable bags according to standard commercial practice. Each bag shall be tagged or labeled. If it is necessary to store the seeds after their arrival on the work site, they shall be stored in an approved weatherproof building in such a manner as to protect the seeds from deterioration and to permit easy access for inspection.
- (c) **General Requirements.**
 - (1) **Variety and Origin.** All seeds shall be guaranteed by the vendor to be true to name and variety. Whenever a particular origin is specified, all seeds furnished shall be guaranteed to be from that origin.
 - (2) **Mixtures.** Seed mixtures shall be proportioned by weight.
 - (3) **Noxious Weed Seeds.** No seeds shall be sown until they have been tested for purity and until such tests indicate that the seeds do not contain any seeds of the noxious weeds classed as "Primary Noxious Weed Seed" and not more than the maximum number per ounce (gram) sample, specified in Table II, Noxious Weeds classed as "Secondary Noxious Weed Seed".
 - (4) **Hard Seeds.** In determining the viable germination percent of legumes, the percent hard seed is to be added to the percent test germination; however, the percent hard seed added shall not exceed the maximum specified in Table II when planted in the fall season.
 - (5) **Seed Purity.** Seeds having a purity that is below the purity specified in Table II will be rejected. Seeds having a total inert matter and weed seed content greater than 20 percent of the sample in cases of bluegrass, redbud, orchard grass, brome grass, and creeping red fescue, and greater than three percent in all other agricultural seeds listed in Table II, will be rejected. Any sample containing more than five percent by weight (mass) of seed of other cultivated plants will be rejected. Seeds that fail to meet the requirements of Table II, "Maximum Weed Seed Percent" and "Remarks", will be rejected.
 - (6) **Pure, Live Seed.** Pure, live seed shall be defined as the sproutable seed of a specified variety and calculated as the product of the viable germination times the purity. The seed weights/acre (kg/ha) listed in Table 1 of Article 250.07, "Seed Mixtures", are designed to yield specific amounts of pure, live seed/ acre (hectare) based on the pure, live seed

percent values listed in Table II of this Article. Seed which has actual pure, live seed yield according to tests less than the intended yield will have the specified quantity adjusted to meet the intended pure, live seed yield. The adjusted weight (mass) to be sown will be calculated as follows.

Adjusted lb/acre (kg/hectare) =
$$\frac{\text{Intended pure live seed per acre (hectare)} \times 100}{\text{Actual pure live seed percent}}$$

Where:

Intended pure live seed per acre (hectare)
(Table 1, Article 250.07) =
$$\frac{\text{Specific lb/acre (kg/hectare)} \times \text{Pure live seed percent}}{\text{(Table II, Article 1081.04)}}$$

Actual pure live seed percent =
$$\frac{\text{Actual germination percent} \times \text{Actual purity percent}}{100}$$

Seeds which meet the noxious weed seed and purity requirements may be sown prior to the completion of the germination test provided an additional amount of seed, specified by the Engineer, is used at no additional cost to the Department.

TABLE II							
Variety of Seeds	Hard Seed	Purity	Pure Live	Weed	Secondary *		Notes
	% Max.	% Min.	Seed % Min.	% Max.	Noxious Weeds Max.	per oz (kg) Permitted	
Alfalfa	20	92	89	0.50	6 (211)		1/
Clover, Alsike	15	92	87	0.30	6 (211)		2/
Red Fescue, Audubon	0	97	82	0.10	3 (105)		-
Red Fescue, Creeping	-	97	82	1.00	6 (211)		-
Red Fescue, Epic	-	98	83	0.05	1 (35)		-
Red Fescue, Sea Link	-	98	83	0.10	3 (105)		-
Tall Fescue, Blade Runner	-	98	83	0.10	2 (70)		-
Tall Fescue, Falcon IV	-	98	83	0.05	1 (35)		-
Tall Fescue, Inferno	0	98	83	0.10	2 (70)		-
Tall Fescue, Tarheel II	-	97	82	1.00	6 (211)		-
Tall Fescue, Quest	0	98	83	0.10	2 (70)		-
Fults Salt Grass	0	98	85	0.10	2 (70)		-
Salty Alkaligrass	0	98	85	0.10	2 (70)		-
Kentucky Bluegrass	-	97	80	0.30	7 (247)		4/
Oats	-	92	88	0.50	2 (70)		3/
Redtop	-	90	78	1.80	5 (175)		3/
Ryegrass, Perennial, Annual	-	97	85	0.30	5 (175)		3/
Rye, Grain, Winter	-	92	83	0.50	2 (70)		3/
Hard Fescue, Reliant IV	-	98	83	0.05	1 (35)		-
Hard Fescue, Rescue 911	0	97	82	0.10	3 (105)		-
Hard Fescue, Spartan II	-	98	83	0.10	3 (105)		-
Timothy	-	92	84	0.50	5 (175)		3/
Wheat, hard Red Winter	-	92	89	0.50	2 (70)		3/

1/ Shall be grown in Kansas or farther north; shall be free from any mixture with southern or foreign seeds, blends or adulterations with screenings, frosted or damaged seeds; and

shall not contain more than 0.2 percent bur or sweet clover mixture.

- 2/ Shall be free from blends or adulterations with screenings, blasted, shriveled, or immature seeds.
- 3/ Shall be recleaned.
- 4/ Shall not contain more than five percent adulteration with Canada Blue Grass, Merion Blue Grass, or other hybrids or varieties of blue grass.
- * No Primary Noxious Weeds are permitted.

- (7) Native Grass Mixture. The seed quantities indicated per acre (hectare) for Prairie Grass Seed in Classes 3, 3A, 4, 4A, 6, and 6A in Article 250.07 shall be the amounts of pure, live seed per acre (hectare) for each species listed. Seed which has actual pure, live seed yield according to tests less than the intended yield, will have the specified quantity adjusted to meet the intended pure, live seed yields.

Thirty days prior to the time of seeding, the Contractor shall provide for the approval of the Engineer, a written description for the Prairie Forbs seed mix showing the percentage by weight (mass) of each of the kinds of seed. This description shall also include the following.

- a. Name and location of the seed supplier.
- b. Origin and date of harvest of each of the various kinds of seed.
- c. A statement of the purity and germination of the seeds.
- d. The estimated number of seeds/lb (kg) of each of the kinds of seed to be furnished.

1081.05 Topsoil and Compost. Topsoil and compost shall be according to the following.

- (a) Topsoil. Topsoil shall be loamy soil from the A horizon of soil profiles of local soils. Loamy soil and the A horizon soil profile are defined in the Geotechnical Manual. The loamy soil shall have an organic content between one and ten percent according to AASHTO T 194. It shall be relatively free from large roots, sticks, weeds, brush, or stones larger than 1 in. (25 mm) in diameter, or other litter and waste products. At least 90 percent shall pass the No. 10 (2.00 mm) sieve according to Illinois Modified AASHTO T 27, and the pH shall be between 5.0 and 8.0 according to ASTM D 4972.

Topsoil shall be capable of supporting and germinating vegetation.

- (b) Compost. Compost shall be thoroughly decomposed organic waste produced at an IEPA registered composting facility. The compost shall have

no glass or metal shards present. Any plastic or other man made material shall be no larger than 1/4 in. (6 mm) and sieved out to be less than one percent of the total dry weight. A copy of the compost test results complying with IEPA standards for General Use Compost and certification of IEPA registration shall be provided to the Engineer with each shipment of compost.

Compost shall be capable of supporting and germinating vegetation.

1081.06 Mulch. Mulch material for seeding and planting shall be non-toxic to vegetation and to the germination of seed. Mulch shall be approved by the Engineer prior to placement.

(a) Mulch for Seeding. Mulch material for seeding shall be as follows.

- (1) Straw. Straw shall be stalks of wheat, rye, oats, or other approved straw, and shall be air dried.
- (2) Hydraulic Mulch. The mulch component shall be comprised of a minimum of 70 percent biodegradable material such as wood cellulose, paper fibers, straw or cotton and shall contain no growth or germination inhibiting factors. The remainder of the components shall consist of the manufacturer's choice of tackifiers and/or strengthening fibers needed to meet the performance specifications. Tackifiers shall be non-toxic and LC 50 test results shall be provided along with the manufacturer's certification. Hydraulic mulch shall disperse evenly and rapidly and remain in slurry when agitated with water. When uniformly applied, the slurry shall form an absorbent cover allowing percolation of water to the underlying surface. Hydraulic mulch shall be packaged in UV and moisture resistant factory labeled packages or bags with the net quantity of the packaged material plainly shown on each package. The biodegradable material shall be relatively free of glossy papers and shall not be water soluble. The hydraulic mulches shall be according to the following.

Light-Duty Hydraulic Mulch	
Property ^{1/}	Value
Functional Longevity ^{2/}	3 months
Minimum Application Rates	2000 lb/acre (2240 kg/ha)
Typical Maximum Slope Gradient (V:H)	≤ 1:3
Maximum Uninterrupted Slope Length	50 ft (15 m)
Maximum C Factor	0.15
Minimum Vegetation Establishment ^{5/}	200 %

Heavy-Duty Hydraulic Mulch	
Property ^{1/}	Value
Functional Longevity ^{2/}	12 months
Minimum Application Rates	3000 lb/acre (3360 kg/ha)
Typical Maximum Slope Gradient (V:H)	≤ 1:2
Maximum Uninterrupted Slope Length	100 ft (30 m)
Maximum C Factor ^{3/ 4/}	0.02
Minimum Vegetation Establishment ^{5/}	400 %

- 1/ This table sets minimum requirements only. Refer to manufacturer recommendations for application rates, instructions, gradients, maximum continuous slope lengths and other site specific recommendations.
- 2/ Manufacturer's estimated time period, based upon field observations, that a material can be anticipated to provide erosion control as influenced by its composition and site-specific conditions.
- 3/ "C" Factor calculated as ratio of soil loss from HECF protected slope (tested at specified or greater gradient, h:v) to ratio of soil loss from unprotected (control) plot based on large-scale testing.
- 4/ Large-scale test methods shall be according to ASTM D 6459.
- 5/ Minimum vegetation establishment shall be calculated according to ASTM D 7322.

The manufacturer shall furnish a certification with each shipment of hydraulic mulch stating the number of packages or bags furnished and that the material complies with these requirements

- (3) Chemical Mulch Binder. Chemical mulch binder shall be a commercially available product specifically recommended by the manufacturer for use as a mulch stabilizer.

The mulch binder shall be nonstaining and nontoxic to vegetation and the environment. It shall disperse evenly and rapidly and remain in suspension when agitated in water. The mulch binder and water suspension or slurry shall be green in color to allow visual metering of its application.

Prior to use of the mulch binder, the Contractor shall submit a notarized certification by the manufacturer stating that it meets these requirements. Chemical mulch binder shall be packaged, stored, and shipped according to the manufacturer's recommendations with the net quantity plainly shown on each package or container.

- (4) **Chemical Compost Binder.** Chemical compost binder shall be a commercially available product specifically recommended by the manufacturer for use as a compost stabilizer.

The compost binder shall be nonstaining and nontoxic to vegetation and the environment. It shall disperse evenly and rapidly and remain in suspension when agitated in water.

Prior to use of the compost binder, the Contractor shall submit a notarized certification by the manufacturer stating that it meets these requirements. Chemical compost binder shall be packaged, stored, and shipped according to the manufacturer's recommendations with the net quantity plainly shown on each package or container.

- (b) **Planting.** The mulch material for planting shall consist of shredded tree bark, wood chips, or other approved organic mulch as specified in the plans.

1081.07 Agricultural Ground Limestone. Agricultural ground limestone shall contain particles ground sufficiently fine so that essentially all material pass a No. 4 (4.75 mm) sieve and is graded relatively uniform through the Nos. 8, 30, and 60 (2.36 mm, 600 μ m, and 250 μ m) sieves. Approved sources of agricultural ground limestone shall be tested by the Department of Agriculture and rated with a source correction factor.

1081.08 Fertilizer. Fertilizer shall be ready-mixed material of an analysis specified on the plans. In cases where a single nutrient is specified, the analysis shall be optional, provided that it carries sufficient filler to ensure adequate distribution of the nutrient.

- (a) The following information shall be shown on the fertilizer bag or package, or on an attached tag.
 - (1) Name and address of manufacturer
 - (2) Name, brand, or trademark
 - (3) Number of net pounds (kilograms) of ready-mixed material in the package
 - (4) Chemical composition or analysis
 - (5) Guarantee of analysis

If a brand or grade of fertilizer is delivered in the bulk, a written statement having the above listed information shall accompany each load.

- (b) Custom mixed fertilizers shall have a written statement containing the following information with each load.
 - (1) Weight of each commercial fertilizer used in the custom mix.

- (2) The guaranteed analysis of each commercial fertilizer used in the custom mix.
- (3) Total weight of fertilizer delivered in each load.
- (4) The manufacturer of each of the commercial fertilizers used in the custom mix.
- (5) Guaranteed analysis of each load to be stated as follows.
 - a. Percent of total Nitrogen (N)
 - b. Percent of total available Phosphoric (P_2O_5)
 - c. Percent of total Soluble Potash (K_2O)
- (6) Name and address of the vendor.

1081.09 Peat Moss. Peat moss shall be as follows.

- (a) Peat moss shall be partially decomposed fibrous or cellular stems and leaves of any of several species of sphagnum mosses and shall be according to the following.
 - (1) Texture and Composition. Its texture shall range from porous fibrous to spongy fibrous, and it shall be either crumbly or compact, but fairly elastic and substantially homogeneous. It shall be free from decomposed colloidal residue, excessive woody materials (roots and stems), and shall be dark brown in color. Shredded particles shall not exceed 1/4 in. (6 mm) in size.
 - (2) Acidity. The pH value shall be not less than 3.2 and not greater than 5.5, at approximately 77 °F (25 °C).
 - (3) Ash. The ash content, based on the oven dry weight (mass) of the material, shall be not more than five percent.
 - (4) Water Holding Capacity. The water holding capacity shall not be less than 400 percent, by weight (mass), on an oven dry basis.
- (b) Sampling. A test sample weighing at least 1 lb (450 g) shall be taken from each 50 ton (45 metric ton) lot or fraction thereof. Such samples shall be taken 6 in. (150 mm) below the surface of one or more bales, thoroughly mixed, and placed in a clean, dry, air tight, metal container or in a strong plastic bag, sealed, and forwarded to the testing laboratory.
- (c) Testing. The samples will be tested according to Article 4.5 of the Federal Specifications for Peat Moss; Peat, Humus; and Peat, Reed-Sedge, Q-P-166e.
- (d) Packing. The air dried peat moss shall be packed in bales of the type, size, and kind commonly used. Damaged bales will not be accepted.

The peat moss shall be packed in the bales at a compression ratio of at least 2 to 1. Each bale shall be clearly marked with the type of peat moss, the brand name, the country of origin, the cubic feet (cubic meter) compressed size, the compression ratio used, and the approximate weight (mass) of the bale. Each shipment shall be accompanied by a certificate stating that the peat moss meets the specified requirements.

1081.10 Erosion Control Blankets. Erosion control blankets shall be fabricated from materials described below, in whole, or in approved combinations of not more than two of the materials described below. When two values are specified, properties of blankets composed of combinations of materials shall be according to the lower of the two values specified for the individual components. Each component shall also meet its individual physical requirements.

- (a) Excelsior Blanket. Excelsior blanket shall consist of a machine produced mat of wood excelsior of 80 percent, 6 in. (150 mm) or longer fiber length. The wood from which the excelsior blanket is cut shall be properly cured to achieve adequately curled and barbed fibers.

The blanket shall be of consistent thickness, with the fiber evenly distributed over the entire area of the blanket. The excelsior blanket shall be covered on the top side with a 90 day biodegradable extruded plastic mesh netting having an approximate minimum opening of 5/8 x 5/8 in. (16 x 16 mm) to an approximate maximum opening of 2 x 1 in. (50 x 25 mm). The netting shall be substantially adhered to the excelsior blanket by a knitting process using biodegradable thread or by an applied degradable adhesive. The netting shall also be entwined with the excelsior blanket for maximum strength and ease of handling.

The excelsior blanket shall also be according to the following.

Parameter	Value
Minimum Width	24 ± 1 in. (600 ± 25 mm)
Weight (Mass)	0.63 lb/sq yd (0.34 kg/sq m) ± 10 %
Minimum Length of Roll	150 ft (45 m), approximate

The excelsior blanket shall be smolder resistant and shall withstand the following test. The excelsior blanket specimen shall not flame or smolder for more than a distance of 12 in. (300 mm) from a spot where a lighted cigarette is placed on the surface of the blanket.

The manufacturer shall furnish a certification with each shipment of excelsior blanket stating the number of rolls furnished and that the material complies with these requirements.

- (b) Knitted Straw Mat. Knitted straw mat shall be a machine-assembled blanket whose primary component is clean, weed free straw from agricultural crops. The straw shall be evenly distributed throughout the blanket to a loose thickness of approximately 1/2 in. (13 mm) with a permissible variation of ± 1/8 in. (± 3 mm). The top side of the blanket shall be covered with

biodegradable plastic mesh of 3/8 x 3/8 in. (10 x 10 mm) square openings with a permissible variation of $\pm 1/8$ in. (± 3 mm) and shall be substantially adhered to the straw by a knitting process using biodegradable thread. The plastic mesh shall degrade within 90 days.

The blanket shall be supplied in a protected rolled mat form of 6 1/2 ft (2 m) minimum width and the average dry weight (mass) shall not be less than 0.50 lb/sq yd (0.27 kg/sq m).

The manufacturer shall furnish a certification with each shipment, stating the number of rolls furnished and that the material complies with these requirements.

- (c) Heavy Duty Erosion Control Blanket. Heavy duty erosion control blanket shall be according to Article 1081.10(a) or (b), except as follows.
 - (1) Excelsior Blanket. The weight (mass) of the wood fiber shall be 1.45 lb/sq yd (0.79 kg/sq m) ± 10 percent. Both the top and bottom side of each blanket shall be covered with a heavy duty extruded plastic mesh which contains an ultraviolet inhibitor and has an opening size of approximately 1/2 x 1/2 in. (13 x 13 mm).
 - (2) Knitted Straw Mat. The minimum weight (mass) of the blanket shall be 0.50 lb/sq yd (0.27 kg/sq m). The material content of the blanket shall be 70 percent straw and 30 percent coconut fiber. The top side of the blanket shall be covered with a two year biodegradable mesh. The bottom side of the blanket shall be covered with a heavy duty extruded plastic mesh which contains an ultraviolet inhibitor and has an opening size of approximately 1/2 x 1/2 in. (13 x 13 mm). The mesh shall be mechanically sewn to the mat at 1.5 in. (38 mm) centers.

The manufacturer shall furnish a certification with each shipment, stating the number of rolls furnished and that the material complies with these requirements.

- (d) Wire Staples. Staples shall be made from No. 11 gauge or heavier uncoated black carbon steel wire of sufficient stiffness for soil penetration. They shall be of the "T" or "U" configuration with pointed ends, 1 to 2 in. (25 to 50 mm) wide at the top and a minimum overall length of 6 in. (150 mm) from top to bottom. The staples for heavy duty erosion control blanket shall be as specified here, except that the legs shall be 8 in. (200 mm) or longer. The staples shall be packaged in cartons.
- (e) Wood Stakes. Hardwood blanket anchors shall be approximately 7 in. (180 mm) long from neck of hook to tip of anchor. The wood shall not break during installation. The anchor shall have a 1/2 in. (13 mm) curving hook to hold the blanket in place.
- (f) Coconut Fiber. Coconut fiber shall only be used in combination with another approved material (straw fiber, wood excelsior, or synthetic fiber) as a form of temporary erosion control blanket.

When used in combination with straw fiber, the blankets shall meet the following fiber densities.

Coconut Fiber Content	30%	0.15 lb/sq yd	(0.08 kg/sq m)
Straw Content	70%	0.36 lb/sq yd	(0.19 kg/sq m)

The blanket shall be supplied in a protected rolled mat form of 6 1/2 ft (2 m) width and the average dry weight (mass) shall not be less than 0.50 lb/sq yd (0.27 kg/sq m).

The manufacturer shall furnish a certification with each shipment, stating the material complies with these requirements and the number of rolls furnished.

- (g) Turf Reinforcement Mat (TRM). The TRM shall be comprised of non-degradable, ultraviolet stabilized synthetic fibers, filaments, netting, and/or wire mesh processed into a three-dimensional reinforced mat. The mats may include degradable material to assist with vegetation establishment. Soil filled mats will not be allowed.

The TRM shall meet the following physical and performance properties:

Property	Value	Test Method
Tensile Strength, lb/ft (kN/m)	150 (2.19) min.	ASTM D 6818
UV Stability, (% Tensile Retained)	80 min.	ASTM D 4355 (1000 Hour Exposure)
Resiliency, (% Thickness Retained)	80 min.	ASTM D 6524
Allowable Shear Stress, lb/sq ft (Pa) ^{1/}	8 (384)	ECTC approved test method and independent laboratory

1/ Minimum shear stress the TRM (fully vegetated) can sustain without physical damage or excess erosion (> 1/2 in. (13 mm) soil loss) during a 30 minute flow event in large scale testing.

For TRMs containing degradable components, all property values must be obtained on the non-degradable portion of the matting alone.

1081.11 Reserved.

1081.12 Reserved.

1081.13 Bracing. Steel posts and earth anchors for bracing shall be as follows.

- (a) Steel Posts. Steel posts for bracing shall be of a type normally used for agricultural fencing; have a steel anchor plate welded or riveted to each post approximately 18 in. (450 mm) from the bottom of the post, be 6 ft (1.8 m) minimum in length, and shall weigh not less than 1 lb/ft (1.5 kg/m). The post shall be finished with a suitable paint of acceptable color or galvanizing unless specified for use as selective mowing stakes. When specified for

selective mowing stakes, the steel posts shall be finished in an acceptable color of green paint. For delineating seedling plantings, the posts shall have the top 10 in. (250 mm) painted with two coats of State equipment orange paint. For delineating native grass, wildflower and ornamental herbaceous plantings, the top 10 in. (250 mm) of the posts shall be painted with two coats of white paint.

- (b) **Earth Anchors.** Earth anchors shall consist of a metal rod with an attached spiral or helical metal anchor plate; and shall be according to the following.

Parameter	Value
Length	42 in. (1 m)
Rod Diameter	5/8 in. (16 mm)
Eye Opening	1 in. (25 mm)
Anchor Plate Diameter	4 in. (100 mm)

1081.14 Weed Barrier Fabric. Weed barrier fabric shall be an approved black, ultraviolet light resistant, nonwoven geotextile fabric with a minimum weight (mass) of 1.75 oz/sq yd (60 g/sq m).

1081.15 Temporary Erosion Control Materials. Temporary erosion control materials shall be as follows.

- (a) **Bale Stakes.** Bale Stakes shall be 4 ft (1.2 m) minimum in length and be either of sound wood 1 in. (25 mm) minimum for one dimension, metal according to Article 1006.28(d), or painted metal posts.
- (b) **Fence Stakes.** Fence stakes, except for silt filter fence, shall be 8 ft (2.4 m) minimum in length metal stakes according to Article 1006.28(d) or painted metal posts. Silt filter fence stakes shall be a minimum of 4 ft (1.2 m) long and made of either wood or metal. Wood stakes shall be 2 in. x 2 in. (50 mm x 50 mm). Metal stakes shall be a standard T or U shape having a minimum weight (mass) of 1.32 lb/ft (600 g/300 mm).
- (c) **Hay or Straw Bales.** Bales shall be either hay or straw compacted and adequately bound to an approximate size of 12 x 18 x 36 in. (300 x 450 x 900 mm).
- (d) **Fence.** Fence shall be a minimum of 4 ft (1.2 m) in height and shall be either snow fence, flexible wooden slat fence, or woven wire fence.
- (e) **Aggregate.** Aggregate shall include any locally available coarse aggregate, stone, broken brick, broken concrete, or riprap. The upstream facing of the aggregate ditch check shall be constructed of gradation CA 3. The remainder of the ditch check shall be constructed of gradation RR 3.
- (f) **Rolled Excelsior.** Rolled excelsior shall consist of an excelsior fiber filling totally encased inside netting and sealed with metal clips or knotted at the ends. The fiber density shall be a minimum of 1.24 lb/cu ft (20 kg/cu m) based on a moisture content of 22 percent at manufacturing. The netting shall be composed of a polyester or polypropylene material which retains

70 percent of its strength after 500 hours of exposure to sunlight. The maximum opening of the net shall be 1 x 1 in. (25 x 25 mm).

- (g) Temporary Erosion Control Seeding. Seeds shall consist of Oats from March 1 to July 31, and Winter Wheat from August 1 to November 15. Seed shall be delivered to the job site in unopened, labeled bags. A certification from the supplier stating the weight (mass) and contents of the bag shall be printed on or attached to each bag along with a certification stating that the seed meets the requirements of Article 1081.04(c).
- (h) Inlet Filters. An inlet filter shall consist of a steel frame with a two piece geotextile fabric bag attached with a stainless steel band and locking cap that is suspended from the frame. A clean, used bag and a used steel frame in good condition meeting the approval of the Engineer may be substituted for new materials. Materials for the inlet filter assembly shall be according to the following.

- (1) Frame Construction. Steel shall be according to Article 1006.04.

Frames designed to fit under a grate shall include an overflow feature that is welded to the frame's ring. The overflow feature shall be designed to allow full flow of water into the structure when the filter bag is full. The dimensions of the frame shall allow the drainage structure grate to fit into the inlet filter assembly frame opening. The assembly frame shall rest on the inside lip of the drainage structure frame for the full variety of existing and proposed drainage structure frames that are present on this contract. The inlet filter assembly frame shall not cause the drainage structure grate to extend higher than 1/4 in. (6 mm) above the drainage structure frame.

- (2) Grate Lock. When the inlet is located in a traffic lane, a grate lock shall be used to secure the grate to the frame. The grate lock shall be according to the manufacturer's requirements for materials and installation.
 - (3) Geotextile Fabric Bag. The sediment bag shall be constructed of an inner filter bag and an outer reinforcement bag.
 - a. Inner Filter Bag. The inner filter bag shall be constructed of a polypropylene geotextile fabric with a minimum silt and debris capacity of 2.0 cu ft (0.06 cu m). The bag shall be according to the following.

Inner Filter Bag		
Material Property	Test Method	Minimum Avg. Roll Value
Grab Tensile Strength	ASTM D 4632	100 lb (45 kg)
Grab Tensile Elongation	ASTM D 4632	50%
Puncture Strength	ASTM D 4833	65 lb (29 kg)
Trapezoidal Tear	ASTM D 4533	45 lb (20 kg)
UV Resistance	ASTM D 4355	70% at 500 hours
Actual Open Size	ASTM D 1420	No. 70 (212 μ m) sieve
Permittivity	ASTM D 4491	2.0/sec
Water Flow Rate	ASTM D 4491	145 gpm/sq ft (5900 Lpm/sq m)

- b. Outer Reinforcement Bag. The outer reinforcement bag shall be constructed of a polyester mesh material according to the following.

Outer Reinforcement Bag		
Material Property	Test Method	Value
Content	ASTM D 629	Polyester
Weight	ASTM D 3776	4.55 oz/sq yd (155 g/sq m) \pm 15%
Whales (holes)	ASTM D 3887	7.5 \pm 2 holes/1 in. (25 mm)
Chorses (holes)	ASTM D 3887	15.5 \pm 2holes/1 in. (25 mm)
Instronball Burst	ASTM D 3887	120 psi (830 kPa) min.
Thickness	ASTM D 1777	0.040 \pm 0.005 in. (1.0 \pm 0.1 mm)

- (4) Certification. The manufacturer shall furnish a certification with each shipment of inlet filters, stating the amount of product furnished and that the material complies with these requirements.
- (i) Urethane Foam/Geotextile. Urethane foam/geotextile shall be triangular shaped having a minimum height of 10 in. (250 mm) in the center with equal sides and a minimum 20 in. (500 mm) base. The triangular shaped inner material shall be a low density urethane foam. The outer cover shall be a woven geotextile fabric placed around the inner material and allowed to extend beyond both sides of the triangle a minimum of 18 in. (450 mm).

- (1) The geotextile shall meet the following properties:

Property	Value	Test Method
Grab Tensile Strength lb (N)	124 (550) min.	ASTM D 4632
Grab Elongation @ Break (percent)	15 min.	ASTM D 4632
Burst Strength psi (kPa)	280 (1930) min.	ASTM D 3786
AOS (Sieve No.)	30 min.	ASTM D 4751
UV Resistance (500 hours) (percent)	80 min.	ASTM D 4355

(2) The urethane foam shall meet the following properties:

Property	Value	Test Method
Density, lb/cu ft (kg/cu m)	1.0 ± 0.1 (16.0 ± 1.6)	ASTM D 3574
Tensile Strength, psi (kPa)	10 (70) min.	ASTM D 3574
Elongation, percent	125 min.	ASTM D 3574
Tear Resistance, lb/in. (N/mm)	1.25 (0.22)	ASTM D 3574

SECTION 1082. PREFORMED BEARING PADS

1082.01 Fabric Bearing Pads. Fabric bearing pads shall consist of a fabric and rubber body made with new unvulcanized rubber and unused fabric fibers.

The rubber body shall be a natural rubber compound known as natural polyisoprene or synthetic rubber known as polychloroprene.

The average surface hardness expressed in standard rubber hardness shall be 80 ± 10 Shore A Durometer.

The ultimate breakdown limit of the pad under compressive loading shall be no less than 7000 psi (48,000 kPa) for the specified thickness without splits or deformations exceeding 10 percent of thickness after removing the load.

The pads shall be furnished to specified dimensions with all dowel holes accurately located. The thickness of fabric bearing pads shall be as shown on the plans within a tolerance of $\pm 1/16$ in. (± 1.5 mm).

SECTION 1083. ELASTOMERIC BEARINGS

1083.01 Description. Elastomeric bearings shall consist of steel laminated elastomeric pads or assemblies of steel laminated elastomeric pads with externally bonded structural steel bearing plates, structural steel top bearing plate, and required stainless steel and PTFE sheets, as shown on the plans and as specified herein.

Shop drawings of the bearing assemblies shall be submitted to the Engineer. The bearing assemblies shall be furnished as a complete unit from one manufacturing source.

The bearing manufacturer shall furnish to the Engineer of Tests at the Bureau of Materials and Physical Research (126 East Ash Springfield, IL 62704) a purchase order for each contract. The purchase order shall contain, as a minimum, the quantity and size of each type of bearing to be furnished.

1083.02 Materials. Materials shall be according to the following.

(a) Properties of the Elastomer. The elastomer compound used in the construction of the bearings shall contain only virgin crystallization resistant

polychloroprene (neoprene) or virgin natural polyisoprene (natural rubber) as the raw polymer. All materials shall be new with no reclaimed material incorporated in the finished bearing. The elastomer compounds shall be classified as being of low-temperature, Grade 3, as specified by the minimum grade requirements of Table 14.7.5.2-2, "Low Temperature Zones and Minimum Grade of Elastomer", of the AASHTO LRFD Bridge Design Specification. Low temperature zones used in this table are as defined in Figure 14.7.5.2-1, "Temperature Zones", of the same publication.

The cured elastomer shall be according to the following requirements. The properties of the cured elastomeric compound material shall be determined using samples taken from actual bearings.

Material Property ^{1/2/}	ASTM Standard	Test Requirements	Polyisoprene (Natural Rubber)	Polychloroprene (Neoprene)
Physical Properties	D 2240	Hardness	55 ± 5 Shore "A" points	55 ± 5 Shore "A" points
	D 412	Min. Tensile Strength	2250 psi (15,500 kPa)	2250 psi (15,500 kPa)
		Min. Ultimate Elongation	400%	400%
Heat Resistance	D 573 at Specified Temp.	Specified Temp. of Test	158 °F (70 °C)	212 °F (100 °C)
		Aging Time	168 hours	70 hours
		Max. Change in Durometer Hardness	+10 Shore "A" points	+15 Shore "A" points
		Max. Change in Tensile Strength	-25%	-15%
		Max. Change in Ultimate Elongation	-25%	-40%
Adhesion ^{3/} to Steel	Illinois Test Procedure 603	Bond Strength (Peel Test)	40 lb/in. (7 N/mm)	40 lb/in. (7 N/mm)
	D 429, B	Adhesion Failure	R-80%	R-80%

1/ All material tests shall be conducted at 73 ± 4 °F (23 ± 2 °C) unless otherwise noted.

2/ For the purpose of determining conformance with this specification, an observed or calculated value shall be rounded off to the nearest 10 psi (100 kPa) for tensile strength, to the nearest ten percent of elongation, and to the nearest one percent for change in aged tensile and aged elongation. Hardness and aged hardness shall be rounded off to nearest point according to AASHTO R 11.

3/ The adhesion failure requirement is waived if bond strength equals or exceeds 80 lb/in. (14 N/mm).

- (b) PTFE Material. The PTFE resin shall be 100 percent virgin material, premium grade, meeting the requirements of ASTM D 4895. The PTFE sheet (polytetrafluoroethylene sheet, premium grade) shall consist of pure

PTFE resin, compression molded and skived into sheets of the required thickness. The finished sheet shall be according to the following.

ASTM Standard	Physical Properties	
D 638 (D 638M)	Tensile Strength	2800 psi min. (19,300 kPa) min.
D 638 (D 638M)	Elongation	200 % min.
D 792	Specific Gravity	2.15 - 2.20
D 2240	Hardness, Durometer D	50 - 65
---	Deformation Under Load 73 °F/100 psi/24 hrs (23 °C/690 kPa/24 hrs) 122 °F/1200 psi/24 hrs (50 °C/8,300 kPa/24 hrs) 73 °F/2000 psi/24 hrs (23 °C/13,800 kPa/24 hrs)	2 - 3 % 4 - 8 % 15 % max.
D 570	Water Absorption	0.01 % max.
---	Static Coefficient of Friction at 500 psi (3450 kPa) bearing pressure on stainless steel	0.07 max.
D 429, B	Adhesion to Steel Peel Strength	25 lb/in. (4.4 N/mm)

- (c) Stainless Steel Sheets. The stainless steel sheets shall be of the thickness specified and shall be according to ASTM A 240, Type 304. The sliding surface shall have a Type 2B finish or smoother as per the American Society of Metals.
- (d) Structural Steel. Structural steel components shall be according to the following.
 - (1) Structural Steel Bearing Plates. The structural steel bearing plates shall be according to the requirements of AASHTO M 270 Grade 36 (M 270M Grade 250).
 - (2) Internal Steel Laminates. The internal steel laminates for the laminated elastomeric bearings shall be rolled mild steel sheets according to AISI 1015 - 1025 inclusive, ASTM A 1008 (A 1008M), or ASTM A 1011 (A 1011M) for less than 3/16 in. (5 mm) thick sheets; or AASHTO M 270, Grade 36 (M 270M, Grade 250) or ASTM A 283 (A 283M) Grade D for 3/16 in. (5 mm) and thicker sheets.
 - (3) Shear Restrictor Pin. The shear restrictor pin, when required, shall be press fit into the bearing plate and shall be alloy steel, quenched, and tempered to a minimum yield strength of 210,000 psi (1,450,000 kPa) or RC hardness of 50 to 55.
 - (4) Threaded Stud. The threaded stud, nuts, and washers, when required, shall be according to the requirements of ASTM A 449 or A 193-B7 and shall be galvanized according to Article 1006.08.

1083.03 Fabrication Requirements. Bearings with steel laminates shall be cast as a unit in a mold and bonded and vulcanized under heat and pressure. The molds shall have standard shop practice mold finish. The internal steel laminates shall be blast cleaned to a condition matching that of SSPC-Vis 1-01, Pictorial

Standard SP6, and additionally cleaned of any oil or grease before bonding. External load plates shall be protected from rusting by the manufacturer, and shall be hot bonded to the bearing during vulcanization. The bond of steel components to and within the elastomeric pads shall be continuous throughout the plan area with no voids or air spaces greater than 0.10 in. (2.5 mm) within the bonding material. Bearings with steel laminates which are designed to act as a single unit with a given shape factor must be manufactured as a single unit. Corners and edges may be rounded with a radius at the corners not exceeding 3/8 in. (10 mm) and a radius at the edges not exceeding 1/4 in. (6 mm).

Bonding of PTFE sheets shall be done as noted on the plans. No rubber flash will be permitted on the edges of PTFE bearing surfaces. All burrs or raised edges along the perimeter of the PTFE surface shall be removed before shipment.

All dimension tolerances shall be according to the following.

Dimensions	Tolerances
Overall vertical dimensions: Design thickness - 1 1/4 in. (32 mm) or less Design thickness - over 1 1/4 in. (32 mm)	- 0, + 1/8 in. (- 0, + 3 mm) - 0, + 1/4 in. (- 0, + 6 mm)
Overall horizontal dimensions: For measurements 36 in. (914 mm) and less For measurements over 36 in. (914 mm)	- 0, + 1/4 in. (- 0, + 6 mm) - 0, + 1/2 in. (- 0, + 13 mm)
Thickness of individual layers of elastomer at any point within the bearing:	± 20 % of design value but no more than ± 1/8 in. (3 mm)
Variation from a plane parallel to the theoretical surface: (as determined by measurements at the edge of the bearings)	
Top	Slope relative to the bottom of no more than 0.005 radians.
Sides	1/4 in. (6 mm)
Position of exposed connection members:	± 1/8 in. (± 3 mm)
Edge cover of embedded steel laminates, restraining devices, holes, and slots:	+ 1/8 in. (+ 3 mm) min. + 1/4 in. (+ 6 mm) max.
Size of holes, slots, or inserts:	± 1/8 in. (± 3 mm)
Position of holes, slots, or inserts:	± 1/8 in. (± 3 mm)

Structural steel bearing plates shall be fabricated according to Article 505.04. Prior to shipment of the bearing assemblies, the exposed edges and other exposed portions of the structural steel bearing plates shall be cleaned and painted according to Articles 506.03 and 506.04. Painting shall be with the inorganic zinc-rich primer according to Article 1008.02. During the cleaning and painting, the stainless steel and PTFE sheet sliding surfaces and the elastomer shall be protected from abrasion and paint.

1083.04 Testing and Acceptance. The rubber laminates shall be of uniform integral units, capable of being separated by mechanical means into separate, well-defined elastomeric layers. The ultimate breakdown limit of the elastomeric bearing under compressive loading shall be not less than 2000 psi (13,800 kPa).

The bearing manufacturer shall load test each completed steel laminated elastomeric bearing pad assembly prior to shipment. The bearings shall be loaded to 1500 psi (10,300 kPa) and under this loading shall exhibit relatively uniform bulging of the rubber layers on all sides and shall show no bond loss or edge splitting. Bearing assemblies under this loading showing nonuniform bulging from one side of the pad to the other, nonuniform bulging along any vertical face of a pad, bulging extending across the specified location of one or more of the internal steel laminates or edge splitting shall be replaced. Nonuniform bulging from one side of the pad to the other may be an indication of lateral misalignment of the internal steel laminates and would not be cause for replacement if probing shows that the edge cover of the steel laminates are within the specified tolerances. Nonuniform bulging along any vertical face of the pad may be an indication of vertical misalignment of the steel laminates and would not be cause for replacement if measurement of the bases of the nonuniform bulges show that the thickness of the elastomeric layers are within the specified ± 20 percent tolerance. Bulging across the specified location of one or more steel laminates indicates missing steel laminates or lack of bond and pads exhibiting these characteristics shall always be replaced.

The Contractor shall furnish certified copies of the bearing manufacturer's test reports on the physical properties of the component materials for the bearings to be furnished and a certification by the bearing manufacturer that the bearings furnished have been load tested and be according to all requirements.

When directed by the Engineer, the Contractor shall furnish random samples of component materials used in the bearings for testing. In addition, when requested in writing by the Engineer, the Contractor shall furnish an additional project bearing assembly to the Department for testing. When the additional bearing assembly is requested, the Engineer retains the right to select the bearing assembly for testing at random from the project lot. The Contractor will be paid for the additional bearing assembly as specified in Article 521.09. If the bearing assembly tested is found to be unacceptable, two additional bearing assemblies will be tested. If both are acceptable, the lot will be accepted. If either of the two additional bearing assemblies are unacceptable, the lot will be rejected. The Contractor shall have a new lot produced, including one additional test bearing. No payment will be made for the original failed bearing assembly or any subsequent test assemblies.

SECTION 1084. ILLUMINATED SIGN

1084.01 Illuminated Sign. The illuminated sign shall be as follows.

- (a) Housing. The sign housing shall be made of extruded aluminum alloy with a minimum thickness of 0.063 in. (1.5 mm). All corners and seams shall be heli-arc welded and weatherproof. Doors shall be made of 0.125 in. (3.1 mm) thick extruded aluminum with a 0.188 x 1 in. (5 x 25 mm) neoprene gasket and sun hood. Hinges shall be continuous full-length stainless steel. Drainage shall be provided by four drain holes at the corners of the housing. The housing shall have stainless steel hardware and provide tool free access to the interior.

The exterior surface of the housing shall be acid-etched and shop painted with one coat of zinc-chromate primer and two coats of yellow enamel. The painting shall be according to Section 851.

- (b) Sign Display. The lens panel shall be 0.125 in. (3.1 mm) ± 10 percent in thickness and shall be made of Plexiglas or other plastic material with equivalent or better weathering, structural, and optical properties. Colors and size of the legend, background, and letters used in the legend shall conform to the MUTCD. Turn prohibition signs shall be according to MUTCD "R3-1" or "R3-2".

When illuminated, the message shall be legible and highly visible within a 15 degree cone centered about the optic axis under any ambient light condition. When the sign is not illuminated, the sign display shall blank-out such that no symbol can be seen under any ambient light condition.

- (c) Illumination. Illumination for the sign shall be as follows.

- (1) Fiber-Optic. The fiber-optic sign shall consist of fiber-optic glass bundles arranged to define the required message. The glass bundles shall be ground smooth and optically polished at the input and output ends for maximum light transmission. The output ends of the fiber-optic glass bundles that form the sign message shall be terminated using glass lenses or glass end caps.

The fiber-optic sign shall control the lamp intensity utilizing the photo control according to Article 1078.01(c)(2)d. The lamp intensity control device shall be wired in series with the step-down transformers in the sign, on the input (120 VAC) side of the transformer. The lamp intensity control device shall be mounted in the bottom of the sign housing. Each fiber-optic sign shall have a separate lamp intensity control device. The lamps shall have a rated minimum life of 5,000 hours.

- (2) Light Emitting Diode (LED). The LED sign shall consist of standard T-13/4 (5 mm) LED lamps and have an expected lamp life of 100,000 hours. Operating wavelengths shall be Red – 626 nm, Amber – 590 nm, and Bluish/Green – 505 nm. The luminance shall be a minimum of 345 candelas/sq ft (3,700 candelas/sq m) when measured normal to the plane of the icon surface under standard operating conditions. The LEDs shall not be aluminum gallium arsenide (AlGaAs) material technology. Transformers shall be rated for the line voltage with Class A insulation and weatherproofing. The sign shall be designed for operation over a range of temperatures from -35 to +165 °F (-37 to +75 °C).

The LED module shall include the message plate, high intensity LEDs and LED drive electronics. Door panels shall be flat black and electrical connections shall be made via barrier-type terminal strip. All fasteners and hardware shall be corrosion resistant stainless steel.

- (d) Mounting Bracket. The mounting bracket shall be according to Article 1078.01(f), except no terminal compartment will be required.

SECTION 1085. GLARE SCREEN BLADES

1085.01 Description. Glare screen blades shall be according to the following.

(a) General.

- (1) The blades shall have a minimum unit weight (mass) of 0.6 lb/ft (0.9 kg/m). (The closed end shall be excluded from the total weight [mass] when determining the unit weight [mass].)
- (2) Blades shall be green in color.
- (3) Blades shall withstand a sharp bend test (180 degree bend without mandrel) at 0 °F (-18 °C) without failure.

(b) Glare Screen Blades. Glare screen blades shall be manufactured of high density polyethylene according to plans details and as follows.

- (1) Wall thickness shall be 0.10 in. (2.5 mm) minimum, except at corners where it shall be 0.06 in. (1.5 mm) minimum.
- (2) Specific gravity of the polyethylene walls shall be between 0.94 and 0.965 as determined by ASTM D 792.
- (3) Tensile strength shall be 3000 psi (20,700 kPa) minimum as determined by ASTM D 638 (D 638M).

(c) Modular Blade-Type Glare Screens. The blade-type screen modules shall be constructed of thermoplastic polyolefin (TPO) having the following physical properties.

- (1) Wall thickness shall be 0.10 in. (2.5 mm) minimum.
- (2) Specific gravity of the thermoplastic polyolefin walls shall be between 0.89 and 0.92 as determined by ASTM D 792.
- (3) Tensile strength shall be 2,610 psi (18,000 kPa) minimum as determined by ASTM D 638 (D 638M).

(d) Base Plates. Base plates shall be fabricated from 1/8 in. (3 mm) minimum steel plate according to AASHTO M 183 (M 183M) and shall be galvanized according to AASHTO M 111 after fabrication.

(e) Anchor Bolts. Anchor bolts shall consist of 3/8 in. (10 mm) expansion anchor studs with nut, flat washer, and lock washer having a minimum pullout strength of 4000 lb (17.7 kN) and shall be zinc coated or stainless steel.

- (f) Self-Tapping Screws. Self-tapping screws shall be stainless steel 5/16 in. (8 mm) diameter x 5/8 in. (16 mm) Large Hex Head Type B and have a 5/16 x 7/8 in. (8 x 22 mm) outer diameter flat washer for each.

ELECTRICAL

SECTION 1086. ELECTRIC SERVICE INSTALLATION

1086.01 Electric Service Installation - Lighting.

- (a) Overhead Electric Service.
 - (1) Service Pole and Appurtenances. The wood service pole shall include a guy and anchor and, if necessary, a meter socket.
 - (2) Weatherhead. The weatherhead shall be designed to fit the service conduit size and galvanized according to AASHTO M 232. It shall be furnished with a composition cover with holes for the service cables.
 - (3) Service Disconnect Switch. A heavy duty service disconnect switch shall be provided on the service pole. It shall be enclosed in a NEMA Type 4X watertight housing. The switch shall have an external lockable handle and shall provide for locking in either the "On" or "Off" position. Fuses and padlocks shall be included.
- (b) Underground Electric Service. When the underground electric service is ground mounted, it shall include a fiberglass above ground pedestal. When the underground electric service is pole mounted, the service disconnect switch shall be according to Article 1086.01(a)(3).

1086.02 Electric Service Installation - Traffic Signal.

- (a) Weatherhead. The weatherhead shall be designed to fit 1 in. (25 mm) threaded conduit, and galvanized according to AASHTO M 232. It shall be furnished with a composition cover with holes for service.
- (b) Circuit Breaker and Weatherproof Enclosure. The circuit breaker shall be single pole, rated 50 A, and mounted on an aluminum plate. The circuit breaker shall be contained in the stainless steel, weatherproof NEMA 4X enclosure of adequate size. The top and bottom of the enclosure shall be furnished with hubs for installing conduits. The enclosure shall be furnished with two padlocks, one for the handle and for the door when used in a Type A service installation. Each padlock shall be furnished with two No. 399 keyed alike keys.
- (c) Grounding. The grounding shall be according to Section 806.

SECTION 1087. GROUNDING**1087.01 Grounding Materials.**

- (a) Grounding Electrode Conductors. Grounding electrode conductors shall be solid, soft drawn 1/C No. 6 copper and shall be installed according to NEC requirements.
- (b) Grounding Electrodes. Grounding electrodes shall be copper-clad steel with a minimum copper thickness of 10 mils (0.3 mm) and UL listed 467. Grounding electrodes shall be one piece, sectional (threaded) steel rods not less than 5/8 in. (16 mm) in diameter and 10 ft (3 m) long.
- (c) Access Wells. Grounding electrode access wells shall be constructed of PVC or composite polyester resin/fiberglass material with a diameter of 8 to 12 in. (200 to 300 mm), a length of 36 in. (900 mm) and a cast iron or composite polyester resin/fiberglass lid, secured via stainless steel hardware. A concrete handhole may be used for the access well according to Article 1088.05.

SECTION 1088. WIREWAY AND CONDUIT SYSTEM

1088.01 Electrical Raceway Materials. Electrical raceway materials shall be as follows.

- (a) Rigid Metal Conduit. The conduit, after fabrication, shall be thoroughly cleaned and the inside and outside surfaces shall be galvanized.

Couplings and fittings shall meet ANSI Standard C 80.1 and shall be hot-dip galvanized. Elbows and nipples shall be according to the specifications for conduit. All fittings and couplings for rigid conduit shall be of the threaded type.

- (1) Rigid Steel Conduit. Rigid steel conduit shall be galvanized and manufactured according to UL Standard 6 and shall meet ANSI Standard C 80.1.
- (2) Intermediate Metal Conduit. Intermediate metal conduit shall be manufactured according to UL Standard 1242 and shall meet ANSI Standard C 80.6.

After fabrication, the conduit shall be thoroughly cleaned and the inside and outside surfaces galvanized.

Couplings and fittings shall meet ANSI Standard C 80.6 and shall be hot-dipped galvanized. All fittings and couplings for conduit shall be the threaded type.

- (3) PVC Coated Galvanized Steel Conduit. The conduit prior to coating shall meet the requirements for rigid metal conduit and be manufactured according to NEMA Standard No. RN1.

The PVC coating shall have the following characteristics.

Hardness	85+ Shore A Durometer
Dielectric Strength	400V/mil @ 60 Hz
Aging	1,000 Hours Atlas Weatherometer
Brittleness Temperature	0 °F (-18 °C) when tested according to ASTM D 746
Elongation	200 percent

The exterior galvanized surfaces shall be coated with a primer before the PVC coating to ensure a bond between the zinc substrate and the PVC coating. The bond strength created shall be greater than the tensile strength of the plastic coating. The nominal thickness of the PVC coating shall be 40 mils (1 mm). The PVC shall pass the following bonding test.

Two parallel cuts 1/2 in. (13 mm) apart and 1 1/2 in. (40 mm) in length shall be made with a sharp knife along the longitudinal axis. A third cut shall be made perpendicular to and crossing the longitudinal cuts at one end. The knife shall then be worked under the PVC coating for 1/2 in. (13 mm) to free the coating from the metal.

Using pliers, the freed PVC tab shall be pulled with a force applied vertically and away from the conduit. The PVC tab shall tear rather than cause any additional PVC coating to separate from the substrate.

A two part urethane coating shall be applied to the interior of the conduit. The internal coating shall have a nominal thickness of 2 mils (0.05 mm). The interior coating shall be applied in a manner so there are no runs, drips, or pinholes at any point. The coating shall not peel, flake, or chip off after a cut is made in the conduit or a scratch is made in the coating. The urethane interior coating applied shall afford sufficient flexibility to permit field bending without cracking or flaking of the interior coating.

All conduit fittings and couplings shall be as specified and recommended by the conduit manufacturer. All conduit fitting covers shall be furnished with stainless steel screws which have been encapsulated with a polyester material on the head to ensure maximum corrosion protection.

- (4) Liquid Tight Flexible Nonmetallic Conduit (LFNC). LFNC shall be manufactured according to UL Standard 1660 Type B. The conduit shall have a temperature range of -20 to 176 °F (-29 to 80 °C). The thermoplastic covering shall be resistant to oil, water, chemical and UV and shall be suitable for outdoor, direct bury, and extreme cold use. Conduit grounding shall be by a separate grounding conductor.

- (5) Aluminum Conduit. Aluminum conduit shall be manufactured of 6063 aluminum alloy, T-1 temper, according to UL Standard 6A and shall meet ANSI Standard C 80.5.
- (b) Rigid Nonmetallic Conduit. The conduit, fittings, and accessories shall be manufactured from polyvinyl chloride complying with ASTM D 1784 and with all the applicable requirements of NEMA Publication No. TC2, UL Standard 651 for EPC-40-PVC.

Fittings and accessories for the electrical plastic conduit shall comply with all applicable requirements of NEMA Publication No. TC3.

The solvent cement used to join the conduit and fittings shall be according to ASTM D 2564.

- (c) Coilable Nonmetallic Conduit. The conduit shall be a polyethylene duct which is intended for underground use and can be manufactured and coiled or reeled in continuous transportable lengths and uncoiled for further processing and/or installation without adversely affecting its properties of performance. The conduit and its manufacture shall be according to the standards of NEMA Publication No. TC-7 and ASTM D 3485.

The conduit shall be made of high density polyethylene which shall meet the requirements of ASTM D 1248, Type III Class C and the requirements listed in Section 3 of NEMA Standard Publication No. TC-7.

Duct dimensions shall be according to the standards listed in Section 3 of NEMA Standard Publication No. TC-7.

Performance Tests. Testing procedures and test results shall meet the requirements of NEMA Standard Publication No. TC 7 Sections 3 and 4. Certified copies of the test report shall be submitted to the Engineer prior to the installation of the conduit.

1088.02 Expansion Fittings for Raceways.

- (a) Metallic Couplings. Expansion couplings for metallic raceways shall consist of an 8 in. (200 mm) expansion fitting plus a deflection fitting which allows for a 3/4 in. (20 mm) deflection. All couplings, except those used indoors, shall have a bonding jumper. Couplings used indoors shall be listed for use without a bonding jumper. Bonding jumpers for exposed metallic raceways shall be external. The coupling may be a combination of the two fittings or a single fitting assembly.
- (b) Non-metallic Couplings. Expansion couplings for non-metallic raceways shall be made of PVC and consist of an 8 in. (200 mm) expansion fitting plus a deflection fitting which allows for a 3/4 in. (20 mm) deflection. The coupling may be a combination of the two fittings or a single fitting assembly.

1088.03 Fasteners and Hardware. Fasteners used to mount conduit supports, boxes, and other items attached to the structure shall be suitable for the weight

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supported and shall be compatible with the structure material. Wood screws shall be used for wood, toggle bolts shall be used for hollow masonry, expansion bolts or power-set studs shall be used for solid masonry or concrete, and clamps shall be used for structural steel.

Expansion anchors and power set anchors shall not be less than 1/4 in. (6 mm) diameter and shall extend at least 2 in. (50 mm) into the masonry or concrete.

All steel hardware shall be hot-dipped galvanized. Hardware for stainless steel boxes and other stainless steel items shall be stainless steel hardware according to Article 1006.31.

Screws for the attachment of pole handhole covers, covers on cast metal boxes, doors on transformer bases, and other such applications shall be stainless steel unless otherwise specified. All stainless steel hardware shall be coated with anti-seize compound.

1088.04 Junction Box. Junction boxes shall be mounted on the surface of a structure or embedded in a structure as shown on the plans. The junction box shall be furnished with a cover, gasket, and hardware. Hardware furnished for the cover shall be stainless steel.

A grounding lug shall be provided in every junction box. A stainless steel conduit fitting shall be used to connect conduit to a stainless steel junction box.

Box covers shall have a continuous formed, seamless, urethane, oil-resistant gasket. The gasket shall be placed directly onto the junction box cover. The gasket shall adhere to the cover without the use of adhesives.

Junction box covers shall be attached to the box with un-slotted hex head screws unless otherwise specified. For boxes mounted on bridge structures, the cover shall be furnished with a retaining chain and captive screws.

Specific requirements for different materials used for junction boxes shall be as follows.

- (a) **Stainless Steel Junction Box.** The box shall be made of Type 304 stainless steel, not less than 14 gauge (2.03 mm), with all seams continuously welded with stainless steel weld wire and ground smooth. Exterior surfaces shall have a smooth polished finish. The box shall be according to NEMA Type 4X and be UL 50 "Junction and Pull Box", "Junction Box", or "Pull Box".

When specified for attachment to a structure, the box shall be suitable for surface mounting, complete with external stainless steel mounting lugs or brackets welded to the box. The box shall have an overlapping stainless steel cover that is secured to the box with a continuous stainless steel hinge and a minimum of four captive stainless steel clamps utilizing captive stainless steel hex-head bolts or deep slotted stainless steel screws.

When specified for embedment in structure, the box shall be constructed with the cover arranged to fit flush with the structure surface. The cover shall be attached with stainless steel unslotted hex-head screws.

- (b) Galvanized Steel Junction Box. The box shall be made of galvanized steel and shall meet the requirements of NEMA 3R and be UL listed. It shall be hot dipped galvanized according to ASTM A 653 (A 653M).

When specified for attachment to a structure, the box shall be suitable for surface mounting, complete with external mounting lugs or brackets welded to the box. Galvanizing shall be done after the lugs or brackets are attached. The box shall have an overlapping cover that is secured to the box with a continuous stainless steel hinge and a minimum of four captive stainless steel clamps utilizing captive stainless steel hex-head bolts or deep slotted stainless steel screws.

When specified for embedment in structure, the box shall be constructed with the cover arranged to fit flush with the structure surface.

- (c) Cast Iron Junction Box. The box shall be made of cast iron, hot dip galvanized, and UL listed, NEMA 4.

When specified for attachment to structure, the box shall be suitable for surface mounting, complete with external mounting lugs integral to the casting. Mounting lugs shall be integral with or securely attached to the box, maintaining the NEMA 4 rating, and galvanizing shall be done after the lugs are attached.

When specified for embedment, the box shall be suitable for encasement in concrete with a flush cover, recessed within an outside flange frame.

Covers shall be attached with hex-head un-slotted silicon bronze screws. The Engineer will determine the application of screws based on the box location.

1088.05 Composite Concrete Handhole. Handholes constructed of a composite concrete shall be designed for off roadway applications subject to occasional, non-deliberate heavy vehicular traffic according to ANSI/SCTE 77 and the following.

- (a) Material. The handhole box and cover shall be constructed of any special combination of fiberglass reinforced polymer concrete and/or fiberglass reinforced polymer, polyester, or plastic material. The handhole material shall be non-conductive and unaffected by ultraviolet light, moisture, and sub-soil chemicals. The color of the top frame and cover shall be concrete gray to match approximately the color of nearby pavement or sidewalks.

The material shall have the following mechanical properties.

Mechanical Property	Strength, psi (kPa)
Compressive Strength	10,300 (71,000)
Tensile Strength	1,700 (11,700)
Flexural Strength	7,500 (51,700)

- (b) Dimensions. The dimensions of the handhole shall be as shown on the plans. The box walls may be smooth or corrugated, straight, or flared, as specified on the plans.
- (c) Cover. The cover of the handhole shall fit flush with the surrounding top frame surface. The minimum thickness of the cover shall be 3/4 in. (20 mm). The cover shall contain a cast-in-place legend "TRAFFIC SIGNALS" or "IDOT LIGHTING" when used for traffic signals or highway lighting, respectively. The cover shall contain either two lifting rings or two lifting slots, as specified on the plans, as follows.

The cover shall contain two recessed slots, each with a recessed stainless steel pin to assist in lifting the cover. The cover shall be held down by two or more stainless steel hex head bolts.

The cover for a double handhole of either cover type shall be a split lid, two-piece cover.

- (d) Load Capacity. Handholes shall meet the structural requirements of Section 7 of ANSI/SCTE 77 for Tier 15 loading.

Written certification shall be submitted to the Engineer that states the handholes provided meet these requirements.

1088.06 Handhole Frame and Cover. The handhole frame and cover shall be fabricated from steel according to Section 505 or cast iron according to AASHTO M 105, Class 30 or better. The dimensions of the frame and cover shall be as shown on the plans. The thickness of the frame and the outer rims of the cover shall be a minimum of 3/4 in. (19 mm). The thickness of the cover, at the center, shall be a minimum of 1 in. (25 mm) at the reinforcing ribs. The frame and cover shall have beveled edges to assist in centering the cover. Each cover of a double handhole shall be connected to the frame by a flush hinge.

The outside of the cover shall contain a recessed ring or handle for lifting and a cast-in-place legend "TRAFFIC SIGNALS" or "IDOT LIGHTING" when used for traffic signals or highway lighting, respectively. The frame and cover shall be designed to withstand AASHTO H-15 loading for a regular handhole and a double handhole, and to withstand AASHTO H-20 loading for a heavy-duty handhole. The frame and cover of a handhole shall have the minimum weight (mass) as follows.

Frame and Cover	Minimum Weight (Mass)
Handhole	140 lb (64 kg)
Heavy-duty Handhole	260 lb (118 kg)
Double Handhole	330 lb (150 kg)

The handhole lifting ring shall have the same or better design life than the handhole cover and frame. The attachment of the lifting ring to the lid by a loaded spring mechanism will not be acceptable.

1088.07 Gulfbox Junction. Cast iron and composite concrete junction boxes shall be as follows.

- (a) Cast Iron Box. The box and cover shall be made of cast iron according to AASHTO M 105, Class 30 or better. The box shall be bottomless and 14 3/4 in. (375 mm) long, 12 in. (305 mm) wide, and 8 in. (203 mm) deep.
- (b) Composite Concrete Box. The box and cover shall be composite concrete according to Article 1088.05. The box shall be bottomless and 14 3/4 in. (375 mm) long, 14 3/4 in. (375 mm) wide, and 12 3/4 in. (324 mm) deep.

SIGNS

SECTION 1090. SIGN BASE

1090.01 Sign Base Material Requirements. The sign base material for Type 1 sign panels shall be sheet aluminum. Type 2 sign panels may be sheet aluminum, bolted aluminum extrusions, or plywood. Type 3 sign panels shall be bolted aluminum extrusions.

<u>Sign Type</u>	<u>Description</u>
Type 1:	6 ft (1.8 m) wide or less and 9 sq ft (0.84 sq m) in area or less.
Type 2:	Over 9 sq ft (0.84 sq m) in area or over 6 ft (1.8 m) wide but less than 24 sq ft (2.22 sq m). (Note 1) (Note 2)
Type 3:	24 sq ft (2.22 sq m) in area or larger.

- Note 1. Plywood may be used only when specified.
- Note 2. On freeways and expressways, Type 2 panels used for guide, information, or service signing shall have the same sign legend as the Type 3 sign panels.

1090.02 Sheet Aluminum. The sign base material shall be flat sheet aluminum to which a chemical conversion coating has been applied. The material shall comply with ASTM B 209, Alloy 6061-T6 or 5052-H 38 and conversion coated according to either MIL-DTL-5541 or ASTM B 449.

Type 1 sign panels shall be at least 0.080 in. (2.03 mm) thick. Type 2 sign panels shall be at least 0.125 in. (3.17 mm) thick. All panels shall be a flat continuous section of the length, width and shape specified in the plans for Standard Sign Design Criteria of the MUTCD with specified mounting holes and corner radii. Sign panels shall be according to dimensions specified, within $\pm 1/32$ in. (± 0.794 mm) and shall not be out of square more than 1/16 in. (1.588 mm). Warps and buckles shall not exceed 1/16 in. (1.588 mm) for each foot in length or width when laid on a true flat surface. All fabrication shall be accomplished prior to the chemical conversion coating process.

Before retroreflective sheeting is applied to the sign panel, the application surface shall be thoroughly cleaned, prepared or etched according to the sheeting manufacturer's recommendations. The chemical conversion coating shall remain

intact on the backside of the sign panel. There shall be no opportunity for the clean metal surface to oxidize or come in contact with grease, oils, or other contaminants prior to the application of reflective sheeting or paint.

1090.03 Bolted Aluminum Extrusions. Sign panels of this type shall be made of aluminum according to ASTM B 221, Alloy 6063-T6.

Panel preparation shall be according to Article 1090.02, except etching may be omitted and holes for demountable sign legend units may be drilled after assembly and reflectorization.

Sign molding shall be an aluminum extrusion designed for the sign panel extrusion with which it is to be used and its color shall match the color of the sign background. The sign molding shall be riveted to the sign panel on 2 ft (600 mm) centers.

Aluminum dome head rivets shall be used to secure the sign molding, sign panel overlays, demountable legend unit, and supplemental panel to the sign face. The dome head rivets shall be 3/16 x 1/4 in. (4.75 x 6.35 mm) blind made from 5052 aluminum with an aluminum alloy mandrel. The dome head rivets shall have a grip range from 0.126 to 0.250 in. (3.2 to 6.4 mm) with a flange diameter of 0.114 in. (2.9 mm) and a rivet length of 0.450 in. (11.4 mm). The dome head rivets shall be color anodized according to the sheeting color of the unit being installed.

All bolts, nuts, and other hardware and material used in assembling aluminum extrusions into sign panels shall be stainless steel and shall be supplied by the manufacturer of the panels. In place of the standard stainless steel post clips the manufacturer may substitute an aluminum post clip meeting the requirements of this specification.

Stainless steel post clips shall be according to ASTM A 276, Type 304. In place of stainless steel post clips the manufacturer may substitute aluminum post clips according to ASTM B 108, 356-T6. A flat washer shall be used under each nut to prevent gouging of the clip.

Stainless steel bolts and washers used for fastening extruded aluminum sign panels to supports, shall be according to ASTM A 276, Type 304. Stainless steel nuts shall be according to ASTM A 240, Type 304. Stainless steel bolts, nuts, and washers shall be used with post clips when installing overhead mounted sign panels.

1090.04 Plywood. Plywood shall be according to AASHTO M 133. Each panel shall bear the mark of an approved testing agency or independent testing laboratory.

If slip sheets are used, they shall not deposit any wax, silicone, or other substance on the surface of the overlays.

There shall be no caulk lubricant residue left on the surface of the overlays that will affect the adhesion of retroreflective sheeting.

Plywood sign panels shall not be used with Type A reflective sheeting.

SECTION 1091. SIGN FACE, SIGN BASE, AND SUPPLEMENTAL PANELS

1091.01 Sign Face Material Requirements. The sign face material shall be in accordance with the Department's Fabrication of Highway Signs Policy.

The sheeting for the background, legend, border, shields, and symbols shall be provided by the same manufacturer

1091.02 Sign Legend and Supplemental Panel Material Requirements. The sign legend and supplemental panel material shall be in accordance with the Department's Fabrication of Highway Signs Policy and the Illinois Manual for Uniform Traffic Control Devices.

Signs shall be fabricated such that the material for the background, legend, border, shields, and symbols are applied in the preferred orientation for the maximum retroreflectivity per the manufacturer's recommendation. When using Type ZZ retroreflective sheeting, the nesting of legend, border, shields, or symbols will not be permitted.

Letters and numerals used shall be according to the standard alphabets for highway signs (available from the Federal Highway Administration) of the series indicated in the design details for the sign.

The finished letters, numerals, symbols, panels, and borders shall show careful workmanship and be clean cut, sharp, and have essentially a plane surface.

- (a) If demountable copy is specified, each demountable legend unit and supplemental panel shall be supplied with mounting holes and shall be secured to the sign face with aluminum dome head rivets with aluminum mandrels and may not be held in place, even temporarily, using any type of adhesive that would damage the sign face, legend unit, or border when removed at a later date. All rivets shall be color matched to the legend or supplemental panel being installed.
- (b) Direct Applied Legend. All direct applied sign legend and borders shall be affixed to clean, dust-free sign panels in a manner specified by the legend manufacturer. The legend and border shall be cut neatly at any intersecting panel edge.

Direct applied retroreflective sheeting and nonreflective sheeting used for legend and border shall be according to Article 1091.03.

The sheeting may be manufactured with a thin aluminum layer between the sheeting and the precoated adhesive.

- (c) Flat Frames. The retroreflective sheeting and nonreflective sheeting used on flat frames for legend and border shall be according to Article 1091.03.

Flat frames shall be 0.032 in. (0.8 mm) aluminum according to ASTM B 209, Alloy 3003-H 14. The frames shall be properly degreased and etched and

treated with a light, tight, amorphous chromate type coating before any sheeting is applied.

- (d) Supplemental Panels. All supplemental panels shall consist of 0.080 in. (2 mm) sheet aluminum according to Article 1090.02 with reflective sheeting applied according to Article 1091.03.

1091.03 Retroreflective and Nonreflective Sheeting and Translucent Overlay Films. The retroreflective sheeting shall serve as the reflectorized background for sign messages and as cutout legends and symbols applied to the reflectorized background. Nonreflective sheeting shall be used as material for cutout legends and symbols applied to the reflectorized background. Translucent overlay films may be used to provide color to white retroreflective sheeting. Messages may be applied in opaque black or transparent colors.

All material furnished under this specification shall have been manufactured within 18 months of the delivery date. All material used to fabricate individual signs shall be supplied by the same manufacturer.

- (a) Retroreflective Sheeting Properties. Retroreflective sheeting shall consist of a flexible, colored, prismatic, or glass lens elements adhered to a synthetic resin, encapsulated by a flexible, transparent plastic having a smooth outer surface. Only suppliers whose products have been tested and approved in the Department's periodic Sheeting Study will be eligible to supply material. All individual batches and or lots of material shall be tested and approved by the Department. The Department reserves the right to sample and test delivered materials according to ASTM D 4956.
- (1) Adhesive. The sheeting shall have a Class 1, pre-coated, pressure sensitive adhesive according to ASTM D 4956. The adhesive shall have a protective liner that is easily removed when tested according to ASTM D 4956. The adhesive shall be capable of being applied to new or refurbished aluminum and reflectorized backgrounds without additional adhesive.
- (2) Color. The sheeting shall be uniform in color and devoid of streaks throughout the length of each roll. The color shall conform to the latest appropriate standard color tolerance chart issued by the U.S. Department of Transportation, Federal Highway Administration and to the daytime and nighttime color requirements of ASTM D 4956. Sheeting used for side by side overlay applications shall have a Hunter Lab Delta E of less than 3.
- (3) Coefficient of Retroreflection. When tested according to ASTM E 810, without averaging, the sheeting shall have a minimum coefficient of retroreflection as shown in the following tables. The brightness of the sheeting when totally wet shall be a minimum of 90 percent of the values shown when tested according to the standard rainfall test specified in Section 7.10.1 of AASHTO M 268-84.

Type A Sheeting
Minimum Coefficient of Retroreflection
candelas/foot candle/sq ft (candelas/lux/sq m) of material

Type A

Observation Angle (deg.)	Entrance Angle (deg.)	White	Yellow	Orange	Red	Green	Blue	Brown
0.2	-4	250	170	100	45	45	20	12
0.2	+30	150	100	60	25	25	12	8.5
0.5	-4	95	65	30	15	15	8	5
0.5	+30	75	50	25	10	10	5	3.5

Type AA Sheeting
Minimum Coefficient of Retroreflection
candelas/foot candle/sq ft (candelas/lux/sq m) of material

Type AA (0 and 90 degree rotation)

Observation Angle (deg.)	Entrance Angle (deg.)	White	Yellow	Red	Green	Blue	FO
0.2	-4	800	660	215	80	43	200
0.2	+30	400	340	100	35	20	120
0.5	-4	200	160	45	20	9.8	80
0.5	+30	100	85	26	10	5.0	50

Type AA (45 degree rotation)

Observation Angle (deg.)	Entrance Angle (deg.)	Yellow	FO
0.2	-4	550	165
0.2	+30	130	45
0.5	-4	145	70
0.5	+30	70	40

Type AP Sheeting
Minimum Coefficient of Retroreflection
candelas/foot candle/sq ft (candelas/lux/sq m) of material

Type AP

Observation Angle (deg.)	Entrance Angle (deg.)	White	Yellow	Red	Green	Blue	Brown	FO
0.2	-4	550	425	100	75	50	30	275
0.2	+30	200	150	40	35	25	15	90
0.5	-4	300	250	60	35	25	20	150
0.5	+30	100	70	20	20	10	5	50

Type AZ Sheeting
Minimum Coefficient of Retroreflection
candelas/foot candle/sq ft (candelas/lux/sq m) of material

Type AZ (0 degree rotation)

Observation Angle (deg.)	Entrance Angle (deg.)	White	Yellow	Red	Green	Blue	FYG	FY
0.2	-4	430	350	110	45	20	325	240
0.2	+30	235	140	60	24	11	200	150
0.5	-4	250	200	60	25	10	235	165
0.5	+30	170	135	40	19	7	105	75
1.0	-4	70	45	10	10	4	70	30
1.0	+30	30	20	7	5	2.5	45	15

Type AZ (90 degree rotation)

Observation Angle (deg.)	Entrance Angle (deg.)	White	Yellow	Red	Green	Blue	FYG	FY
0.2	-4	320	250	100	45	20	300	220
0.2	+30	235	140	40	24	11	200	150
0.5	-4	240	200	60	25	10	235	165
0.5	+30	100	85	20	10	7	80	75
1.0	-4	30	30	7	5	4	65	20
1.0	+30	15	15	5	2	2	30	10

Type ZZ Sheeting
Minimum Coefficient of Retroreflection
candelas/foot candle/sq ft (candelas/lux/sq m) of material

Type ZZ (0 degree rotation)

Observation Angle (deg.)	Entrance Angle (deg.)	White	Yellow	Red	Green	Blue	FYG	FY	FO
0.2	-4	725	545	145	75	35	580	435	255
0.2	+30	300	225	60	30	15	240	180	105
0.5	-4	450	340	90	45	20	360	270	160
0.5	+30	180	135	40	20	10	145	110	65
1.0	-4	130	100	30	15	6	105	80	50
1.0	+30	70	55	15	10	3	60	45	25

Type ZZ (90 degree rotation)

Observation Angle (deg.)	Entrance Angle (deg.)	White	Yellow	Red	Green	Blue	FYG	FY	FO
0.2	-4	415	305	85	42	17	340	145	85
0.2	+30	80	60	18	14	4.4	64	48	23
0.5	-4	350	260	70	35	16	280	210	80
0.5	+30	75	56	15	12	3.6	60	45	25
1.0	-4	110	80	18	11	4.8	87	64	22
1.0	+30	20	13	3	2	1	12	9	3

- (4) **Durability.** When processed and applied, the sheeting shall be weather resistant. Accelerated laboratory weathering will be used for provisional qualification of sheeting before the results from accelerated outdoor weathering are available. When they become available, the results from outdoor weathering take precedence over the results from laboratory-accelerated weathering tests.

Accelerated weathering testing will be performed for 1000 hours (300 hours for orange/FO) according to ASTM G 151. The testing cycle will consist of 8 hours of light at 140 °F (60 °C), followed by 4 hours of condensation at 104 °F (40 °C). Following accelerated weathering, the sheeting shall exhibit a minimum of 80 percent of its initial minimum coefficient of retroreflection as listed in the previous tables. The sheeting shall exhibit a Hunter Lab Delta E of 5 or less when compared to the original.

Outdoor weathering will entail an annual evaluation of material placed in an outdoor rack with a 45 degree angle and a southern sun exposure. The sheeting will be evaluated for five years. Following weathering, the test specimens will be cleaned by immersing them in a five percent hydrochloric acid solution for 45 seconds, then rinsed with water and blotted dry with a soft clean cloth. Following cleaning, the applied sheeting shall show no appreciable discoloration, cracking, streaking, crazing, blistering, or dimensional change. The sheeting shall exhibit a Hunter Lab Delta E of 5 or less when compared to the original.

- (5) **Shrinkage.** When tested according to ASTM D 4956, the sheeting shall not shrink in any dimension more than 1/32 in. (0.8 mm) in ten minutes and not more than 1/8 in. (3 mm) in 24 hours.
- (6) **Workability.** The sheeting shall show no cracking, scaling, pitting, blistering, edge lifting, inter-film splitting, curling, or discoloration when processed and applied using mutually acceptable processing and application procedures.
- (7) **Adhesive Bond.** The sheeting shall form a durable bond to smooth, corrosion-resistant, and weather-resistant surfaces and adhere securely when tested according to ASTM D 4956.
- (8) **Positionability.** Sheeting, with ASTM D 4956 Class 3 adhesive, used for manufacturing cutout legends and borders shall provide sufficient positionability during the fabrication process to permit removal and reapplication without damage to either the legend or sign background and shall have a plastic liner suitable for use on bed cutting machines. Thereafter, all other adhesive and bond requirements contained in the specification shall apply.

Positionability shall be verified by cutting 4 in. (100 mm) letters E, I, K, M, S, W, and Y out of the positionable material. The letters shall then be applied to a sheeted aluminum blank using a single pass of a 2-lb (0.90-kg) roller. The letters shall sit for five minutes and then a putty

knife shall be used to lift a corner. The thumb and fore finger shall be used to slowly pull the lifted corner to lift letters away from the sheeted aluminum. The letters shall not tear or distort when removed.

- (9) Thickness. The thickness of the sheeting without the protective liner shall be less than or equal to 0.015 in. (0.4 mm), or 0.025 in. (0.6 mm) for prismatic material.
- (10) Processing. The sheeting shall permit cutting and color processing according to the sheeting manufacturer's specifications at temperatures of 60 to 100 °F (15 to 38 °C) and within a relative humidity range of 20 to 80 percent. The sheeting shall be heat resistant and permit forced curing without staining the applied or unapplied sheeting at temperatures recommended by the manufacturer. The sheeting shall be solvent resistant and capable of being cleaned with VM&P naphtha, mineral spirits, and turpentine.

Transparent color and opaque black inks shall be single component and low odor. The inks shall dry within eight hours and not require clear coating. After color processing on white sheeting, the sheeting shall show no appreciable discoloration, cracking, streaking, crazing, blistering, or dimensional change when tested for durability (4). The ink on the weathered, prepared panel shall exhibit a Hunter Lab Delta E of 5 or less when compared to the original.

Transparent color electronic cutting films shall be acrylic. After application to white sheeting, the films shall show no appreciable discoloration, cracking, streaking, crazing, blistering, or dimensional change when tested for durability (4). The films on the weathered, prepared panel shall exhibit a Hunter Lab Delta E of 5 or less when compared to the original.

Transparent colors screened, or transparent acrylic electronic cutting films, on white sheeting, shall meet the minimum initial coefficient of retroreflection values of the 0.2 degree observation angle, -4.0 degree entrance angle values as listed in the previous tables for the color being applied. After durability testing, the colors shall retain a minimum 80 percent of the initial coefficient of retroreflection.

- (11) Identification. The sheeting shall have a distinctive overall pattern in the sheeting unique to the manufacturer. If material orientation is required for optimum retroreflectivity, permanent orientation marks shall be incorporated into the face of the sheeting. Neither the overall pattern nor the orientation marks shall interfere with the retroreflectivity of the sheeting.
- (12) Packaging. Both ends of each box shall be clearly labeled with the sheeting type, color, adhesive type, manufacturer's lot number, date of manufacture, and supplier's name. Material Safety Data Sheets and technical bulletins for all materials shall be furnished with each shipment.

- (b) Nonreflective Sheeting Properties. Nonreflective sheeting shall consist of a flexible, pigmented cast vinyl film having a smooth, flat outer surface and shall meet the following requirements. The Department reserves the right to sample and test delivered materials according to ASTM D 4956.
- (1) Adhesive. The sheeting shall have a Class 1, pre-coated, pressure sensitive adhesive according to ASTM D 4956. The adhesive shall have a protective liner that is easily removed when tested according to ASTM D 4956. The adhesive shall be capable of being applied to new or refurbished aluminum and reflectorized backgrounds without additional adhesive.
 - (2) Color. The sheeting shall be uniform in color and devoid of streaks throughout the length of each roll.
 - (3) Gloss. The sheeting shall exhibit a minimum 85 degree gloss-meter rating of 40 when tested according to ASTM D 523.
 - (4) Durability. Applied sheeting that has been vertically exposed to the elements for seven years shall show no appreciable discoloration, cracking, crazing, blistering, delamination, or loss of adhesion. A slight amount of chalking is permitted but the sheeting shall not support fungus growth.
 - (5) Testing. Test panels shall be prepared by applying the sheeting to 6 1/2 x 6 1/2 in. (165 x 165 mm) pieces of aluminum according to the manufacturer's specifications. The edges of the panel shall be trimmed evenly and aged 48 hours at 70 to 90 °F (21 to 32 °C). Shrinkage and immersion testing shall be as follows.
 - a. Shrinkage. The sheeting shall not shrink more than 1/64 in. (0.4 mm) from any panel edge when subjected to a temperature of 150 °F (66 °C) for 48 hours and shall be sufficiently heat resistant to retain adhesion after one week at 150 °F (66 °C).
 - b. Immersion Testing. The sheeting shall show no appreciable decrease in adhesion, color, or general appearance when examined one hour after being immersed to a depth of 2 or 3 in. (50 or 75 mm) in the following solutions at 70 to 90 °F (21 to 32 °C) for specified times.

Solution	Immersion Time (hours)
Reference Fuel (M I L-F-8799A) (15 parts xylol and 85 parts mineral spirits by weight)	1
Distilled Water	24
SAE No. 20 Motor Oil	24
Antifreeze (1/2 ethylene glycol, 1/2 distilled water)	24

- (6) **Adhesive Bond:** The sheeting shall form a durable bond to smooth, corrosion-resistant, and weather-resistant surfaces and adhere securely when tested according to ASTM D 4956.
- (7) **Thickness.** The thickness of the sheeting without the protective liner shall be a maximum of 0.005 in. (0.13 mm).
- (8) **Cutting.** Material used on bed cutting machines shall have a smooth plastic liner.
- (9) **Packaging.** Both ends of each box shall be clearly labeled with the sheeting type, color, adhesive type, manufacturer's lot number, date of manufacture, and supplier's name. Material Safety Data Sheets and technical bulletins for all materials shall be furnished with each shipment.

SECTION 1092. RESERVED

SECTION 1093. SIGN SUPPORTS

1093.01 Structural Steel Supports. The structural steel shall have a silicone content suitable for galvanizing.

- (a) **Breakaway.** All structural steel shall be according to AASHTO M 270 (M 270M).

After fabrication, the post, fuse plate, base plate, and upper 6 in. (150 mm) of the stub post shall be galvanized according to AASHTO M 111. Bolts and nuts on the fuse plates may be plated according to ASTM B 633 (B 633M) SC3 and then painted with an approved zinc rich paint.

All high strength bolts, nuts, and washers shall be according to Article 1006.08(b).

- (b) **Tubular.** Hollow structural steel tubing shall be according to ASTM A 500 Grade B or ASTM A 501.

After fabrication, the post, base plate, and upper 6 in. (150 mm) of the stud post shall be galvanized according to AASHTO M 111.

All high strength bolts, nuts, and washers shall be according to Article 1006.08(b).

- (c) **Telescoping.** The post shall be a square tube formed of 12 gauge steel according to the standard specification for cold rolled carbon steel sheets commercial quality ASTM A 1008 (A 1008M). The post shall be formed to size and, if necessary, shall be welded in such a manner that weld or flash shall not interfere with telescoping. Holes $7/16 \pm 1/64$ in. (11 ± 0.4 mm) will be spaced on 1 in. (25 mm) centers on at least two opposite sides. The holes shall align to accept a 3/8 in. (10 mm) bolt through the post at any

location. The post shall have a smooth galvanized finish applied either before or after forming.

The following tolerances will be permitted.

The nominal outside dimension will not vary more than ± 0.008 in. (± 0.2 mm) [± 0.10 in. (± 2.5 mm) for the 2 1/4 in. (57 mm) size] from the dimension stipulated. The wall thickness will not vary more than $+0.011$ to -0.008 in. ($+0.28$ to -0.20 mm) from the standard 12 gauge plate thickness. The maximum allowable twist in a 3 ft (1 m) length and the permissible variation in squareness shall be as shown in the following table.

Post Size	Squareness	Twist
1 3/4 x 1 3/4 in.	± 0.010 in.	0.062 in.
2 x 2 in.	± 0.012 in.	0.062 in.
2 1/4 x 2 1/4 in.	± 0.014 in.	0.062 in.

Post Size	Squareness	Twist
44 x 44 mm	± 0.25 mm	1.7 mm
51 x 51 mm	± 0.30 mm	1.7 mm
57 x 57 mm	± 0.35 mm	1.7 mm

The posts shall be straight and have a smooth uniform finish. It shall be possible to telescope all consecutive sizes of posts freely and for at least 10 ft (3.0 m) of their length without the necessity of matching any particular face to any other face. All holes and ends shall be free from burrs and ends shall be cut square.

The posts shall be hot-dipped galvanized according to AASHTO M 111, or given triple coated protection by in-line application of hot-dip galvanized zinc per AASHTO M 111 followed by a chromate conversion coating and a cross-linked polyurethane acrylic exterior coating. The inside surfaces shall be given corrosion protection by in-line application of a full zinc base organic coating after fabrication, tested in accordance with ASTM B 117. If a weld process is performed after galvanizing, the weld shall be zinc-coated after the scarfing operation.

1093.02 Base for Telescoping Sign Support. The base shall be cast from iron meeting the requirements of ASTM A 126, Class A. The finished casting shall be free from burrs, cracks, voids, or other defects.

Castings shall be galvanized by either the hot-dipped process according to AASHTO M 232 or mechanical plating method according to AASHTO M 298, Class 50 with a maximum coating of 3.5 oz/sq ft (1077 g/sq m).

The nominal inside dimension of the square hole shall not vary more than 1/16 in. (2 mm) from the dimension shown on the plans.

1093.03 Reserved.

SECTION 1094. OVERHEAD SIGN STRUCTURES

1094.01 General. Materials used in the fabrication of overhead sign structures, including their supports and walkways, shall be according to the specifications set forth in the plans and the following.

1094.02 Anchor Rods, Nuts, and Washers. Anchor rods shall be according to Article 1006.09, Grade 105 (Grade 725) and galvanized for the entire length shown on the plans.

1094.03 Conduit. All conduit furnished shall be 3 in. (75 mm) nominal size and shall comply with ANSI C 80.1 or 80.5. The interior and exterior surfaces of steel conduit shall be galvanized.

1094.04 Mounting Hardware. Carbon steel bolts, nuts, and washers shall be according to ASTM A 307, Grade A and shall be hot dip galvanized according to AASHTO M 232, Class D.

1094.05 Structural Aluminum. The aluminum alloys to be welded under these specifications may be any of the following ASTM designations.

- (a) **Aluminum Fabrication.** Aluminum shall be assembled, welded, and inspected according to ANSI/AWS D1.2, "Structural Welding Code-Aluminum", except as herein modified.
- (b) **Load-carrying Elements.** All primary load carrying elements shall be evaluated as Class I structures according to ANSI/AWS D1.2, "Structural Welding Code-Aluminum".

Wrought nonheat-treatable alloys: Alloy 3003 and Alloy 3004.

Wrought heat-treatable alloys: Alloy 6061 and Alloy 6063.

Cast heat-treatable alloys: ASTM B 108, Alloy A 356.0-T61 for permanent mold castings; ASTM B 26, Alloy 520.0-T4 or A356.0-T6 for sand castings; or ASTM B 618, Alloy 520.0-T4 or A3256.0-T6 for investment castings. All castings shall have a radiographic discontinuity level according to Grade C, 1/4 in. (6 mm) section thickness.

Material used for permanent backing shall be at least equivalent in weldability to the base metal being welded.

- (c) **Welding Processes.** These specifications include provisions for welding by the gas metal-arc process and the gas tungsten-arc process. Other processes shall not be used, except as permitted by the Engineer.

Tungsten electrodes for the gas tungsten-arc process shall be according to the requirements of the latest edition of Specification for Tungsten-Arc Welding Electrodes, AWS A 5.12.

Filler metals to be used with particular base metals shall be as shown in Table 1. Other filler metals may be used as approved by the Engineer or as specified in the plans.

Table 1	
Base Metal	Filler Metal
3003 to 3003	ER1100
3004 to 3004	ER4043
3003 to 6061	ER5183 or 5356
6061 to 6061	ER5356 *
6063 to 6063	ER5356 *
A356-T61 or A444-T4 to 3003	ER4043 or 4145
A356-T61 or A444-T4 to 6061	ER4043 or 4145
A356-T61 or A444-T4 to 6063	ER4043
A356-T61 to A356-T61	ER4043
A444-T4 to A444-74	ER4043

* ER5356 and ER5556 may be used interchangeably for these base metals.

Filler metals shall be kept covered and stored in a dry place at relatively uniform temperatures. Original rod or wire containers shall not be opened until time to be used. Rod and wire shall be free of moisture, lubricant, or other contaminants. Spools of wire temporarily left unused on the welding machine shall be kept covered to avoid contamination by dirt and grease collecting on the wire. If a spool of wire is to be unused for more than a short length of time, it shall be returned to the carton and the carton tightly resealed.

- (d) **Shielding Gases.** Shielding gas for gas metal-arc welding shall be argon, helium, or a mixture of the two (approximately 75 percent helium and 25 percent argon).

Shielding gas for gas tungsten-arc welding done with alternating current shall be argon.

Shielding gas for tungsten-arc welding done with direct current, straight polarity, shall be helium.

Hose used for shielding gases shall be made of synthetic rubber or plastic. Natural rubber hose shall not be used. Hose that has been previously used for acetylene or other gases shall not be used.

- (e) **Preparation of Materials.** Joint details shall be according to design requirements and detail drawings. The locations of joints shall not be changed without the approval of the Engineer.

Edge preparation shall be by sawing, machining, clipping, or shearing. Cut surfaces shall meet the American Standards Association's surface roughness rating value of 1,000. Oxygen cutting shall not be used.

Surfaces and edges to be welded shall be free from fins, tears, and other defects that would adversely affect the quality of the weld.

Dirt, grease, forming or machining lubricants, or any organic materials shall be removed from the areas to be welded by cleaning with a suitable solvent or by vapor degreasing.

The oxide shall be removed from all edges and surfaces to be welded just prior to welding by wire brushing or by other mechanical methods, such as rubbing with steel wool or abrasive cloth, scraping, filing, rotary planing, or sanding. If wire brushing is used, the brushes shall be made of stainless steel. Hand or power driven wire brushes and other mechanical devices that have been used on other materials shall not be used on aluminum.

Where mechanical methods of oxide removal are found to be inadequate, a standard chemical method shall be used. Welding shall be done within 24 hours after chemical treatment.

When gas tungsten-arc welding with direct current, straight polarity, is being used, all edges and surfaces to be welded shall have the oxide removed by a standard chemical method.

Welding shall not be done on anodically treated aluminum unless the condition is removed from the joint area to be welded.

- (f) Welding Procedure. All butt welds requiring 100 percent penetration, except those produced with the aid of backing, shall have the root of the initial weld chipped or machined out to sound metal before welding is started from the second side. Butt welds made with the use of backing shall have the weld metal thoroughly fused with the backing. Where accessible, backing for welds that are subject to computed stress or which are exposed to view on the completed structure and which are not otherwise parts of the structure shall be removed and the joints ground or machined smooth. In tubular members, butt welds subjected to computed stresses shall be made with the aid of permanent backing rings or strips.

The procedure used for production welding of any particular joint shall be the same as used in the procedure qualification for the joint.

All welding operations, either shop or field, shall be protected from air currents or drafts so as to prevent any loss of gas shielding during welding. Adequate gas shielding shall be provided to protect the molten metal during solidification.

The work shall be positioned for flat position welding whenever practicable.

In both shop and field, all weld joints shall be dry at time of welding.

The size of the electrode, voltage and amperage, welding speed, gas or gas mixture, and gas flow rate shall be suitable for the thickness of the material, design of joint, welding position, and other circumstances influencing the

work, and shall be shown on the approved Weld Procedure Specification (WPS).

Gas metal-arc welding shall be done with direct current, reverse polarity.

Gas tungsten-arc welding shall be done with alternating current or straight polarity direct current.

The Contractor shall submit to the Engineer, at his request, two weld samples for destructive testing and macroetching. These samples shall be welded according to the procedures that will be used in production welding. The Contractor shall submit to the Engineer for approval, the procedure to be used for the test samples and production welding. Should test of these samples indicate unsatisfactory welding, additional samples shall be furnished without cost to the Department. Poor workmanship as noted by visual inspection shall be sufficient cause for rejection.

Where preheat is needed, the temperature of preheat shall not exceed 350 °F (177 °C) for nonheat-treated alloys. The temperature shall be measured by temperature indicating crayons, contact or accurate $[\pm 3.6 \text{ °F } (\pm 2 \text{ °C})]$ non-contact pyrometric equipment. Heat-treated alloys shall not be held at or near the maximum preheat temperature for more than 35 minutes.

- (g) Welding Quality. Regardless of the method of inspection, the acceptance or rejection of welds shall comply with the D1.2 Code and the following conditions.

Welds having defects exceeding the levels of acceptance specified shall be considered as rejected unless corrected according to Article 1094.05(i).

Undercut shall not be more than 0.01 in. (0.25 mm) deep when its direction is transverse to the primary stress in the part that is undercut. Undercut shall not be more than 1/32 in. (0.80 mm) deep when its direction is parallel to the primary stress in the part that is undercut. When undercut is present, the affected area shall be ground to a smooth transition.

- (h) Nondestructive Examination/Nondestructive Testing (NDE/NDT). To determine compliance with these specifications, all welds shall be visually inspected and, in addition, complete joint penetration welds subjected to computed stress shall be inspected by radiographic testing (RT) for butt welds and ultrasonic testing (UT) for T and corner joints. RT shall utilize aluminum edge blocks and location marks similar to those specified for steel in Article 505.04 in addition to the D1.2 requirements.

The dye penetrant testing (DPT) shall be performed according to ASTM E 165, Standard Methods for Liquid Penetrant Inspection, Method B, Procedure B-2 or B-3. DPT shall be used on partial joint penetration and fillet welds as follows: 100 percent of the top and bottom cantilever truss chords to connection and gusset plates near column; 25 percent of top connection plate to collar; 100 percent of simple span splice flanges to main chords; and random 10 percent of main chords to diagonals, horizontals, and verticals as directed by the Engineer.

Dye penetrant inspection may be omitted, provided the inspector examines each layer of weld metal with a magnifier of 3X minimum before the next successive layer is deposited.

Required NDE/NDT shall be the responsibility of the Contractor and its cost shall be included in the fabrication.

- (i) Corrections. In lieu of rejection of an entire member containing welding that is unacceptable, the corrective measures may be permitted by the Engineer, if the extent of repairs will not adversely affect the structure's serviceability.

Defective welds shall be corrected by removing and replacing the entire weld or as permitted by D1.2 Code. Copper or tungsten inclusions shall be completely removed.

Before rewelding, the joint shall be inspected to assure all of the defective weld has been removed. If dye penetrant has been used to inspect the weld, all traces of penetrant solutions shall be removed with solvent, water, heat, or other suitable means before rewelding.

Repaired areas shall be 100 percent inspected by RT, UT, or DPT as applicable.

- (j) Qualification of Procedures, Welders, and Welding Operators. Joint welding procedures that are to be employed under these specifications shall be qualified by tests prescribed in the D1.2 Code. The qualifications shall be at the expense of the Contractor. The Engineer may accept properly documented evidence of previous qualification of the joint welding procedures to be employed.

All welders and welding operators shall be qualified by tests specified by the D1.2 Code. The Engineer may accept properly documented evidence of previous qualification of the welders and welding operators to be employed.

1094.06 Structural Steel. All structural steel pipe shall be ASTM A 53 Grade B or A 500 Grade B or C. All structural steel plates and shapes shall be according to AASHTO M 270, Grades, 36, 50, or 50 W (M 270M, Grades 250, 345, or 345W), M 183 (M 183M), M 223 Grade 50 (M 223M, Grade 345) or M 222 (M 222M). Stainless steel for shims and handhole covers shall be ASTM A 240, Type 302 or 304, or another alloy suitable for exterior exposure and acceptable to the Engineer. Steel to be hot dip galvanized shall have a silicon content either less than 0.04 percent or between 0.15 percent and 0.25 percent.

SECTION 1095. PAVEMENT MARKINGS

1095.01 Thermoplastic Pavement Markings. This material shall be a mixture of resins and other materials providing an essentially nonvolatile thermoplastic compound especially developed for traffic markings.

(a) **Ingredient Materials.**

- (1) **Binder.** The binder shall consist of a mixture of synthetic resins, at least one of which is solid at room temperature. The solid resin shall be a hydrocarbon or alkyd resin. The total binder content of the thermoplastic compound shall be well distributed throughout the compound. The binder shall be free from all foreign objects or ingredients that would cause bleeding, staining, or discoloration. The binder shall be 18 percent minimum by weight of the thermoplastic compound. The binder shall be characterized by an IR Spectra. Future shipments of binder will be checked by an IR Spectra to verify that the binder has not been changed.
- (2) **Pigment.** The pigment used for the white thermoplastic compound shall be a high-grade pure (minimum 93 percent) titanium dioxide (TiO₂). The white pigment content shall be a minimum of ten percent by weight and shall be uniformly distributed throughout the thermoplastic compound.

The pigments used for the yellow thermoplastic compound shall not contain any hazardous materials listed in the Environmental Protection Agency Code of Federal Regulations (CFR) 40, Section 261.24, Table 1. The combined total of RCRA listed heavy metals shall not exceed 100 ppm when tested by X-ray fluorescence spectroscopy. The pigments shall also be heat resistant, UV stable and color-fast yellows, golds, and oranges, which shall produce a compound which shall match Federal Standard 595 Color No. 33538. The pigment shall be uniformly distributed throughout the thermoplastic compound.

- (3) **Filler.** The filler to be incorporated with the resins as a binder shall be a white calcium carbonate, silica, or an approved substitute. Any filler which is insoluble in 6N hydrochloric acid shall be of such particle size as to pass a No. 100 (150 µm) sieve.
- (4) **Glass Beads.** The glass beads used as intermix beads with the thermoplastic pavement marking material shall meet the requirements of Article 1095.07. The glass beads shall be uniformly mixed throughout the material at the rate of not less than 30 percent by weight of the thermoplastic compound, retained on a No. 100 (150 µm) sieve.

(b) **Thermoplastic Compound.**

(1) **Characteristic Requirements.**

- a. In the plastic state, the material shall not give off fumes that are toxic or otherwise injurious to persons or property. The

manufacturer shall provide material safety data sheets for the product.

- b. The temperature versus viscosity characteristic of the plastic material shall remain constant and the material shall not deteriorate in any manner during reheating processes.
- c. There shall be no obvious change in color of the material as a result of repeated heatings or from batch to batch. The maximum elapsed time after application after which normal traffic will leave no impression or imprint on the new stripe shall be two minutes at 50 °F (10 °C) or five minutes at 90 °F (32 °C) pavement temperature. After application and proper drying, the material shall show no appreciable deformation or discoloration, shall remain free from tack, and shall not lift from the pavement under normal traffic conditions within a road temperature range of -20 to 150 °F (-29 to 66 °C). The stripe shall maintain its original color, dimensions and placement.

Cold ductility of the material shall be such as to permit normal dimensional distortion as a result of traffic impact within the temperature range specified.

- d. The material shall provide a stripe that has a uniform color and thickness throughout its cross section and has the density and character to provide a sharp edge of the line.
- e. Daylight Reflectance and Color. The thermoplastic compound after heating for four hours \pm five minutes at 425 \pm 3 °F (218.3 \pm 2 °C) and cooled at 77 °F (25 °C) shall meet the following requirements for daylight reflectance and color, when tested, using a color spectrophotometer with 45 degree circumferential/zero degree geometry, illuminant C, and two degree observer angle. The color instrument shall measure the visible spectrum from 380 to 720 nm with a wavelength measurement interval and spectral bandpass of 10 nm.

White	Daylight Reflectance	75 % min.
Yellow *	Daylight Reflectance	75 % min.

*Shall meet the coordinates of the following color tolerance chart.

x	0.490	0.475	0.485	0.530
y	0.470	0.438	0.425	0.456

- f. Specific Gravity. After heating the thermoplastic for four hours \pm five minutes at 425 \pm 3 °F (218.3 \pm 2 °C), the specific gravity of the thermoplastic material shall be from 1.8 to 2.4 when determined according to ASTM D 153, Method A, using kerosene as the immersion liquid.

- g. Water Absorption of Plastics. The material shall have not more than 0.5 percent by weight of retained water when tested by ASTM D 570, "Water Absorption of Plastics," Procedure (a).
- h. Softening Point. After heating the thermoplastic material for four hours \pm five minutes at 425 ± 3 °F (218.3 ± 2 °C) and testing in accordance with ASTM E 28, the material shall have a softening point between 200 to 240 °F (93.3 to 115.6 °C) as measured by the ring and ball method.
- i. Tensile Bond Strength. After heating the thermoplastic material for four hours \pm five minutes at 425 ± 3 °F (218.3 ± 2 °C), the tensile bond strength to unprimed, sandblasted portland cement concrete block, 0.0625 in. (1.587 mm) thick film drawn down at 425 °F (218.3 °C), tested at 75 ± 2 °F (23.9 ± 1 °C) shall exceed 150 psi (1,030 kPa) when tested according to ASTM D 4796.
- j. Yellowness Index. After heating the thermoplastic for four hours \pm five minutes at 425 ± 3 °F (218.3 ± 2 °C), the white thermoplastic material shall not exceed a yellowness index of 12 when tested in accordance with ASTM D 1925.
- k. Accelerated Weathering. After heating the thermoplastic for four hours \pm five minutes at 425 ± 3 °F (218.3 ± 2 °C), the thermoplastic shall be applied to a steel wool abraded aluminum alloy panel (Federal Test Std. No. 141, Method 2013) at a film thickness of 30 mils (0.75 mm) and allowed to cool for 24 hours at room temperature. The coated panel shall be subjected to accelerated weathering using the light and water exposure apparatus (fluorescent UV - condensation type) for 75 hours according to ASTM G 53 (equipped with UVB-313 lamps).

The cycle shall consist of four hours UV exposure at 122 °F (50 °C) followed by four hours of condensation at 104 °F (40 °C). UVB 313 bulbs shall be used. At the end of the exposure period, the panel shall not exceed 10 Hunter Lab Delta E units from the original material.

- (2) Packaging. The thermoplastic material shall be packaged in suitable containers which will not adhere to the product during shipment and storage. The container of thermoplastic material shall weigh approximately 50 lb (22.7 kg), and shall be delivered on pallets, 40 containers per pallet. The lot size shall be approximately 44,000 lb (20,000 kg) unless the total order is less than that amount.

Each container of material shall be stenciled with the manufacturer's name, the type of material (alkyd or hydrocarbon), color of material (white or yellow), IDOT specification number (1095.01), the month and year the material was packaged and the lot number. Lot numbers must begin with the last two digits of the year manufactured and be sequential with lot 1; i.e., the first lot manufactured in 1997 should be

labeled 97-1. The letters and numbers used in the stencils shall be a minimum of 1/2 in. (12.7 mm) in height.

- (3) **Storage Life.** The material shall maintain a granular free-flow condition in dry storage for a minimum of one year, providing the temperature does not exceed 104 °F (40 °C). The thermoplastic must also melt uniformly with no evidence of skins or unmelted particles and meet all requirements of this specification for one year after delivery. Any material not meeting the above requirements shall be disposed of by the vendor and immediately replaced with acceptable material entirely at his expense, including handling and transportation charges.

(c) **Sampling and Inspection.**

- (1) The manufacturer shall forward preliminary samples of thermoplastic and ingredient materials to the Engineer of Materials and Physical Research, 126 East Ash Street, Springfield, Illinois, 62704-4766 for testing. The thermoplastic and ingredient materials shall be representative of the materials used/made and may not be changed without approval of the Department. All samples shall be provided in friction-top metal containers in the quantities specified. (Approximately 30 days are required to complete testing of the qualification samples.)

a. **Ingredient Materials.**

1. Glass beads. 1 qt (1 L)
2. Binder. 1 pt (0.5 L)
3. Pigments. 1 pt (0.5 L)
4. Filler. 1 pt (0.5 L)

b. **Thermoplastic.** 1 gal (4 L)

- (2) **Sampling and Testing.** Unless otherwise provided, all materials shall be sampled and tested in accordance with the latest published standard methods of the American Society for Testing and Materials, and revisions thereof, in effect on the date of the invitation for bids, where such standard methods exist. In case there are no ASTM Standards which apply, applicable standard methods of the American Association of State Highway and Transportation Officials, or the Federal Government, or of other recognized standardizing agencies shall be used. The sample(s) shall be labeled with the shipment number if applicable, lot number, date, quantity and any other pertinent information.

Thermoplastic. At least three randomly selected containers shall be obtained from each lot. A 1 gal (4 L) composite sample of the three containers shall be submitted for testing and acceptance.

- (3) **Inspection.** All material samples for acceptance tests shall be taken or witnessed by a representative of the Bureau of Materials and Physical

Research and shall be submitted to the Engineer of Materials and Physical Research, 126 East Ash Street, Springfield, Illinois 62704-4766 at least 30 days in advance of the pavement marking operations. The right is reserved to inspect the material either at the place of manufacture or at the destination or at both places. If inspected at the place of manufacture, the manufacturer shall furnish such facilities as may be required for collecting and forwarding samples, and shall also furnish facilities for testing the material during the process of manufacture, if required. Tests will be made by and at the expense of the Department. Random check samples may be taken at the job site at the discretion of the Engineer.

(d) Manufacturer's Responsibility.

- (1) The manufacturer shall perform tests on a minimum of one sample per 10,000 lb (4,500 kg) of thermoplastic produced. Minimum tests required shall be a softening point determination and color. Manufacturer's test results shall be submitted along with the thermoplastic sample to the Bureau of Materials and Physical Research.
- (2) The manufacturer shall retain the test sample for a minimum period of 18 months.
- (3) The manufacturer shall furnish the Bureau of Materials and Physical Research with copies of bills of lading for all material inspected. Bills of lading shall indicate the consignee and destination, date of shipment, lot numbers, quantity, type of material, name and location of source.

(e) Material Acceptance. Final acceptance of a particular lot of thermoplastic will be based on the following.

- (1) Compliance of ingredient materials with the specifications.
 - (2) Compliance of thermoplastic material with the specifications.
 - (3) Manufacturer's test results for each lot of thermoplastic have been received.
 - (4) Identification requirements are satisfactory.
- (f) Glass Beads. The glass beads used as drop on beads with the thermoplastic pavement marking material shall meet the requirements of Article 1095.07, Type B. The beads shall be applied uniformly at a minimum rate of 8 lb/100 sq ft (39 kg/100 sq m).

1095.02 Paint Pavement Markings. All materials shall meet the following paint specification unless a shortage of raw materials precludes the production of paint which will meet the materials portion of this section. If the shortage can be documented to the satisfaction of the Engineer, then an alternate formulation will be allowed. Any alternate formulation shall comply with the latest volatile organic matter

(VOM) content limits published by the IEPA in Title 35, Part 223 of the Illinois Administrative Code.

The finished paint shall be formulated and manufactured from first-grade materials. It shall be free from defects and imperfections that might adversely affect the serviceability of the finished product. It shall be completely free from dirt and other foreign material and shall dry within the time specified to a good, tough, serviceable film. The paint shall show no evidence of excessive settling, gelling, skinning, spoilage or living upon storage in the sealed shipping containers under normal above freezing temperatures within twelve months of delivery. Any settled portion shall be easily brought back into suspension by hand mixing. When the settled portion is brought back into suspension in the vehicle, the paint shall be homogeneous and shall not show a viscosity change of more than 5 KU from the original viscosity. Any paint that has settled within the period of twelve months after delivery to the degree that the settled portion cannot be easily brought into suspension by hand mixing shall be disposed of by the vendor and immediately replaced with acceptable material entirely at his expense, including handling and transportation charges. The paint, when applied by spraying methods to a hot-mix asphalt pavement, shall not be discolored due to the solvent action of the paint on the surface.

(a) Ingredient Materials.

- (1) Titanium Dioxide. This material shall comply with the latest revision of the Specification for Titanium Dioxide Pigments, ASTM D 476, Type II, Rutile. A notarized certificate of compliance from the pigment manufacturer shall be required.
- (2) Yellow Pigment. This material shall be a non-toxic organic pigment, Yellow 65: Engelhard 1244 or equivalent.
- (3) Calcium Carbonate. This material shall comply with the latest revision of the Specification for Calcium Carbonate Pigments, ASTM D 1199, Type GC, Grade I, with minimum of 95 percent Calcium Carbonate or Type PC, minimum 98 percent Calcium Carbonate.
- (4) Acrylic Emulsion Polymer. This material shall be Rohm and Haas 2706 or Dow Chemical DT-211.
- (5) Methyl Alcohol. This material shall comply with the latest revision of the Specification for Methyl Alcohol, ASTM D 1152.
- (6) Miscellaneous Materials.
 - a. Water: Potable
 - b. Dispersant: Tamol 850 (Rohm and Haas) or equivalent
 - c. Surfactant: Triton CF-10 (Union Carbide) or equivalent
 - d. Defoamer: Colloids 654 (Rhône-Poulenc) or equivalent

- e. Rheology Modifier: Natrasol 250 HBR (Aqualon Company) or equivalent
 - f. Coalescent: Texanol (Eastman Chemical)
 - g. Preservative: Troy 192 (Troy Chemical) or equivalent
- (b) Manufacture. All ingredient materials shall be delivered in the original containers and shall be used without adulteration. The containers shall be marked with type of material, name of manufacturer and lot number.

The manufacturer shall furnish to the Department the batch formula which will be used in manufacturing the paint.

No change shall be made in this formula without prior approval by the Department and no change will be approved that adversely affects the quality or serviceability of the paint.

The following Standard Formulas shall be the basis for the paint. The finished products shall conform on a weight basis to the composition requirements of these formulas. No variations will be permitted, except for the replacement of volatile lost in processing. Amounts are shown in pounds (kilograms) of material.

	White	Yellow
	lb (kg)	lb (kg)
C.I. Pigment Yellow 65	---	32 (14.52)
Titanium Dioxide, Rutile, Type II	100 (45.36)	21 (9.53)
Calcium Carbonate, Type PC	150 (68.04)	150 (68.04)
Calcium Carbonate, Type GC	430 (195.05)	465 (210.92)
Rheology Modifier	0.5 (0.23)	0.5 (0.23)
Acrylic Emulsion, 50% Solids	541 (245.40)	535 (242.68)
Coalescent	24 (10.89)	23 (10.43)
Defoamer	5 (2.27)	5 (2.27)
Dispersant	8 (3.63)	9 (4.08)
Surfactant	2 (0.91)	2 (0.91)
Methyl Alcohol	29 (13.15)	28 (12.70)
Preservative	1.5 (0.68)	1.5 (0.68)
Water	10 (4.54)	10 (4.54)
Total	1301 (590.15)	1282 (581.53)

- (c) Paint Properties. The finished paint shall be according to the following.

- (1) Pigment. Analysis of the extracted pigment shall be according to the following.

	White	Yellow
Organic Yellow 65 (%)	---	Min. 4.8
Titanium Dioxide (%)	Min. 13.4	Min. 2.8
Calcium Carbonate (%)	Max. 86	Max. 93

The percent pigment by weight of the finished product shall not be less than 50 percent nor more than 54 percent.

- (2) **Vehicle.** The non-volatile portion of the vehicle shall be composed of a 100 percent acrylic polymer and shall not be less than 44 percent by weight.
- (3) **Organic Volatiles.** The finished paint shall contain less than 150 grams of volatile organic matter per liter of total paint. (ASTM D 3960)
- (4) **Total Solids.** The finished paint shall not be less than 73 percent total non-volatile by weight. (ASTM D 2369)
- (5) **Unit Weight.** The unit weight at 77 °F (25 °C) of the production batches shall not vary more than plus or minus 0.20 lb/gal (0.024 kg/L) from the weight of the qualification samples.
- (6) **Viscosity.** The consistency of the paint shall not be less than 83 nor more than 98 Kreb units at 77 °F (25 °C).
- (7) **Dry Opacity.** The minimum contrast ratio shall be 0.97 when tested in accordance with Federal Specification, Method 141 a, No. 4121, Procedure B when applied at a wet film thickness of 15 mils (0.38 mm).
- (8) **Color And Directional Reflectance.** The paint, applied at a wet film thickness of 15 mils (0.38 mm) and allowed to dry 24 hours, shall meet the following requirements for daylight reflectance and color, when tested, using a color spectrophotometer with 45 degrees circumferential/zero degree geometry, illuminant C, and two degree observer angle. The color instrument shall measure the visible spectrum from 380 to 720 nm with a wavelength measurement interval and spectral bandpass of 10 nm.

White	Daylight Reflectance (Y)	85 % min.
Yellow *	Daylight Reflectance (Y)	50 % min.

*Shall match Federal 595 Color No. 33538 and chromaticity limits as follows.

x	0.490	0.475	0.485	0.530
y	0.470	0.438	0.425	0.456

- (9) **Water Resistance.** The paint shall be according to Federal Specification TT-P-1952D, Section 3.2.5.
- (10) **Freeze-Thaw Stability.** The paint shall show no coagulation or change in consistency greater than 10 Kreb Units, when tested according to Federal Specification TT-P-1952D, Section 4.3.8.
- (11) **Accelerated Package Stability.** The paint shall show no coagulation, discoloration, or change in consistency greater than 10 Kreb Units when tested according to Federal Specification TT-P-1952D, Section 4.3.4.

- (12) Dilution Test. The paint shall be capable of dilution with water at all levels without curdling or precipitation such that the wet paint can be readily cleaned up with water only.
 - (13) Storage Stability. After 30 days storage in a three-quarters filled, closed container, the paint shall show no caking that cannot be readily remixed to a smooth, homogenous state, no skinning, livering, curdling or hard settling. The viscosity shall not change more than 5 Kreb units from the viscosity of the original sample.
 - (14) No Pick-Up Time. The no pick-up time shall be less than 10 minutes. The test shall follow the requirements of ASTM D 711 with a wet film thickness of 15 mils (0.38 mm).
 - (15) Grind. The paint shall have a grind of not less than 3 on a Hegman Grind Gauge.
 - (16) Flexibility. The paint shall show no cracking or flaking when tested according to Federal Specification TT-P-1952D, Section 4.3.5.
 - (17) Dry Through Time. The paint, when applied to a non-absorbent substrate at a wet film thickness of 15 mils (0.38 mm) and placed in a humidity chamber controlled at 90 ± 5 percent R.H. and 72.5 ± 2.5 °F (22.5 ± 1.4 °C) shall have a "dry through time" not greater than 15 minutes of the IDOT standard formula. The dry through time shall be determined according to ASTM D 1640, except that the pressure exerted shall be the minimum needed to maintain contact with the thumb and film.
 - (18) No-Tracking Time Field Test. The paint shall dry to a no-tracking condition under traffic in three minutes maximum when applied at 15 ± 1 mil (0.38 ± 0.03 mm) wet film thickness at $130 - 150$ °F ($54.4 - 65.6$ °C), and from three to ten minutes when applied at ambient temperatures with 6 lb (0.72 kg) of glass beads per gal (L) of paint. "No-tracking" shall be the time in minutes required for the line to withstand the running of a standard automobile over the line at a speed of approximately 40 mph (65 km/hr), simulating a passing procedure without tracking of the reflectorized line when viewed from a distance of 50 ft (15 m).
- (d) Sampling and Inspection.
- (1) Sample. The manufacturer shall forward to the Engineer of Materials and Physical Research, 126 East Ash Street, Springfield, Illinois 62704-4766, for test purposes, three 1 pt (1/2 L) qualification samples of material representative of that which he/she proposes to produce.

Along with the samples, the paint manufacturer shall furnish a copy of his/her batching formula and a list of the trade names and manufacturers of the ingredient materials proposed for use. Product data sheets shall be provided as verification of the ingredient materials conformity with the specification requirements. No changes shall be made without prior approval by the Department.

- (2) Sampling and Testing. Unless otherwise provided, all materials shall be sampled and tested in accordance with the latest published standard methods of the American Society for Testing and Materials, and revisions thereof, in effect on the date of manufacture, where such standard methods exist. In case there are no ASTM Standards which apply, applicable standard methods of the American Association of State Highway and Transportation Officials, or of the Federal Government, or of other recognized standardizing agencies shall be used.
- (3) Inspection. The right is reserved to inspect the paint either at the place of manufacture or after its arrival at destination. If inspected at the place of manufacture, the manufacturer shall furnish such facilities as may be required for collecting and forwarding samples of ingredient materials and finished paint and for performing the inspection of the paint during the process of manufacture. Before manufacture of the paint is started, the ingredient materials shall be set aside at the manufacturer's plant and shall be sampled by an authorized representative of the Department. All materials represented by these samples shall be held until tests have been made and the materials found to comply with the requirements of the specifications. Approximately 30 days are required to test the ingredient materials. The Department has the option to waive inspection of ingredient materials. During the manufacturing operations, the Department's representative shall have free entry at all times to such parts of the plant as concern the manufacture of the paint. All tests will be made by and at the expense of the Department.

All material samples for acceptance tests shall be taken or witnessed by a representative of the Bureau of Materials and Physical Research and shall be submitted to the Engineer of Materials and Physical Research, 126 East Ash Street, Springfield, Illinois 62704-4766.

- (e) Packaging. Unless otherwise directed, the paint shall be packaged and shipped in new 55 gal removable head, steel drums meeting the latest regulations of the United States Department of Transportation for shipping containers for this type of material. The drums shall be lined with a non-corrosive lining compatible with the waterborne paint. The opening in the drum shall be circular, and the diameter of the opening shall be substantially the diameter of the inside of the end of the drum. The drum shall be provided with gaskets of one-piece tubular neoprene construction and shall be completely airtight. The closure shall be securely attached to the drum by a bolt-action-type ring that shall enclose the edge of the lid and the chime of the drum. The closure bolt shall be tightened to a minimum of 40 ft lb (54 N m) torque, and a lock nut shall be securely tightened against the threaded end of the anchor. The white paint shall be packaged in white drums with white lids, and the yellow paint shall be packaged in white drums with yellow lids.

Fifty-five gallons of paint shall be placed in each drum, leaving approximately 2 in. (5 cm) of air space. The paint will be measured by volume, the unit of measure being a gallon [231 cu in. at 77 °F (25 °C)].

Each drum shall be stenciled on the removable head and on the side to show the kind of paint contained therein, the manufacturer's name, the lot number, and the month and year the paint is packaged.

- (f) Glass Beads. The glass beads used as drop on beads with the pavement marking paint shall be according to the requirements of Article 1095.07, Type B.

1095.03 Preformed Plastic Pavement Markings. The material shall consist of white or yellow (as specified) weather resistant reflective film according to the requirements specified herein.

- (a) Composition. The preformed plastic marking shall consist of high quality plastic materials, pigments, and glass beads and shall be furnished with a pressure sensitive precoated adhesive.

The markings shall have the following minimum composition without adhesive.

Components	Minimum Percent By Weight
Resins and Plasticizers	20 %
Pigment and Fillers	30 %
Graded Glass Beads	25 %

The remaining percentage shall be comprised of the above materials in various proportions.

- (b) Conformability and Resealing. The marking shall be according to pavement contours, breaks, faults, etc. through the action of traffic at all pavement temperatures. The film shall have resealing characteristics and shall be capable of fusing with itself or with previously applied marking material.
- (c) Thickness. Prior to application, the thickness of the material, without adhesive, shall be at least 60 mils (1.50 mm).

The Type B material shall feature an embossed pattern with a minimum thickness of 65 mils (1.65 mm) measured at the thickest point of the patterned cross section and a minimum of 20 mils (0.508 mm) measured at the thinnest point of the cross section.

- (d) Durability and Wear Resistance. The markings, when properly applied, shall provide a neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. The markings shall provide a cushioned resilient substrate that reduces bead crushing and loss. The markings shall be weather resistant and, through normal traffic wear, show no appreciable fading, lifting, tearing, rollback, or other signs of poor adhesion.
- (e) Skid Resistance. The surface of the markings shall provide the following minimum skid resistance values when tested according to ASTM E 303.

Type B	45 BPN
Type C	55 BPN

- (f) Tensile Strength. The material shall have the following minimum tensile strength of cross section when tested according to ASTM D 638-76 using a jaw speed of 10 to 12 in./min (250 to 300 mm/min).

Type B	Not Applicable
Type C	150 psi (1033 kPa)

- (g) Elongation. The material shall have the following minimum elongation when tested according to ASTM D 638-76 using a jaw speed of 10 to 12 in./min (250 to 300 mm/min).

Type B	Not Applicable
Type C	50%

- (h) Glass Beads. Glass beads shall be uniformly distributed throughout the markings. A top coating of beads shall be bonded to or directly embedded into the surface of the markings in order to produce immediate retroreflectivity.

The glass beads shall be colorless and have a minimum index of refraction of 1.50 when tested using the liquid immersion method.

Type B material shall have an innermix of glass beads with a minimum index of refraction of 1.50 and a top coating of ceramic beads bonded to top urethane wear surface with a minimum index of refraction of 1.70. Beads with an index of refraction greater than 1.80 shall not be used.

Type C material shall have a layer of skid resistant ceramic particles bonded to the top urethane wear surface. The urethane wear surface shall have a nominal thickness of 5 mils (0.13 mm).

The bead adhesion shall be such that beads are not easily removed when the film is scratched firmly with a thumb nail.

- (i) Plastic Pull Test. A test specimen of 1 x 3 in. (25 x 75 mm) shall support a dead weight of 4 lb (1.8 kg) for not less than five minutes at a temperature between 70 and 80 °F (21 and 27 °C).
- (j) Pigmentation. The pigment for the white preformed plastic compound shall be a high grade pure (minimum 89 percent) titanium dioxide (TiO₂). The white pigment content shall not be less than ten percent by weight and shall be uniformly distributed throughout the compound.

The pigment used for the yellow preformed plastic compound shall be colorfast yellows, golds, and oranges. The yellow pigment content shall not be less than three percent by weight and shall be uniformly distributed throughout the compound.

- (k) Color. The material shall meet the following requirements for daylight reflectance and color, when tested, using a standard color difference meter (0 degrees, 45 degrees) and a magnesium oxide standard or an approved secondary standard.

Type B		
White	Daylight reflectance, Y	65% min.
*Yellow	Daylight reflectance, Y	36 to 59%

Type C		
White	Daylight reflectance, Y	80% min.
*Yellow	Daylight reflectance, Y	36 to 59%

*Shall match Federal Highway Color Tolerance Chart, PR Color No. 1 December 1972.

- (l) Reflectance. The white and yellow films shall have the following initial minimum reflectance values at 0.2 degrees and 0.5 degrees observation angles and 86.0 degrees entrance angle as measured according to the testing procedures of Federal Test Method Standard 370. The photometric quantity to be measured shall be Specific Luminance (SL), and shall be expressed as millicandelas/footcandle/sq ft (millicandelas/lux/sq m). The test distance shall be 50 ft (15 m) and the sample size shall be a 1.0 x 2.0 ft (300 x 600 mm) rectangle. The angular aperture of both the photoreceptor and light projector shall be six minutes of arc. The reference center shall be the geometric center of the sample, and the reference axis shall be taken perpendicular to the test sample.

Type B				
Entrance Angle Observation Angle Specific Luminance	White		Yellow	
	86°	86.5°	86°	86.5°
	0.2°	1.0°	0.2°	1.0°
	1100	700	800	500

Type C				
Entrance Angle Observation Angle Specific Luminance	White		Yellow	
	86°	86°	86°	86°
	0.2°	0.5°	0.2°	0.5°
	700	500	410	250

- (m) Identification. The material delivered to the jobsite shall be identified by the same shipment number(s), if applicable, batch or lot number(s), as the sample(s) tested and approved for that job. The batch or lot number(s) of the material, and the month and year the material is packaged, shall be stenciled or embossed on the container or included on the label.
- (n) Sampling and Testing. All material samples for acceptance tests will be taken or witnessed by a representative of the Bureau of Materials and Physical Research and will be submitted to the Engineer of Materials and Physical Research, 126 East Ash Street, Springfield, Illinois 62704-4766.

Random check samples may be taken at the jobsite at the discretion of the Engineer.

The Engineer will test and certify the basic requirements.

The Contractor shall provide the Engineer certification from the manufacturer that the material to be furnished meets all the requirements of these specifications.

Sample(s) of preformed plastic shall be a minimum of 2 sq ft (0.2 sq m) of each color to be used.

The sample(s) shall be labeled with the shipment number(s), if applicable, batch or lot number(s), all batch number(s) comprising a lot, date, quantity, and any other pertinent information.

1095.04 Epoxy Pavement Marking. All materials shall be according to the following.

- (a) The epoxy marking material shall consist of a 100 percent solid two part system formulated and designed to provide a simple volumetric mixing ratio of two components (must be two volumes of Part A and one volume of Part B). No volatile solvents or fillers will be allowed. Total solids shall not be less than 99 percent when determined, on the mixed material, according to ASTM D 2369, excluding the solvent dispersion.
- (b) The Epoxide Value (WPE) of Component A shall be tested according to ASTM D 1652 on a pigment free basis. The WPE shall not vary more than plus or minus 50 units of the qualification samples.
- (c) The Total Amine Value of Component B shall be tested according to ASTM D 2074. The Total Amine Value shall not vary more than plus or minus 50 units of the qualification samples.
- (d) Composition by Weight of Component A as Determined by Low Temperature Ashing. A 0.5 gram sample of component A shall be dispersed with a paperclip on the bottom of an aluminum dish, weighed and then heated in a muffle furnace at 1000 °F (538 °C) for one hour and weighed again. No solvents shall be used for dispersion. The difference in the weights shall be calculated and meet the following.

Pigment*	White	Yellow
Titanium Dioxide ASTM D 476 Type II	21-24%	
Organic Yellow, Titanium Dioxide, Other		± 2%**
Epoxy Resin	76-79%	± 2%**

* No extender pigments are permitted.

** From the pigment and epoxy resin content determined on qualification samples.

- (e) Upon heating to application temperature, the material shall not exude fumes which are toxic or injurious to persons or property.
- (f) The daylight directional reflectance of the paint (without glass spheres) applied at 14 to 16 mils (0.35 to 0.41 mm) shall meet the following requirements when tested, using a color spectrophotometer with 45 degree circumferential/zero degree geometry, illuminant C, and two degree observer angle. The color instrument shall measure the visible spectrum from 380 to 720 nm with a wavelength measurement interval and spectral bandpass of 10 nm.

White	Daylight Reflectance (Y)	80 % min.
Yellow*	Daylight Reflectance (Y)	50 % min.

*Shall meet the coordinates of the following color tolerance chart.

x	0.490	0.475	0.485	0.530
y	0.470	0.438	0.425	0.456

- (g) The epoxy pavement marking material, when mixed in the proper mix ratio and applied at 14 to 16 mils (0.35 to 0.41 mm) wet film thickness and with the proper saturation of glass spheres, shall exhibit a dry no pick-up time of twenty minutes or less when tested according to ASTM D 711.
- (h) The epoxy pavement marking material, when mixed in the proper mix ratio and tested according to ASTM D 7234 shall have a degree of adhesion which results in a 100 percent concrete failure in the performance of this test.
- (i) The epoxy pavement marking materials when tested according to ASTM D 2240, shall have a shore D hardness of between 75 and 100. Films shall be cast on a rigid substrate at 14 to 16 mils (0.35 to 0.41 mm) in thickness and allowed to cure at room temperature for 72 hours before testing.
- (j) The abrasion resistance shall be evaluated, according to ASTM D 4060, on a Taber Abrader with a 1,000 gram load and CS 17 wheels. The duration of test shall be 1,000 cycles. The loss shall be calculated by difference and be less than 82 mgs. The tests shall be run on cured samples of material which have been applied at a film thickness of 14 to 16 mils (0.35 to 0.41 mm) to code S-16 stainless steel plates. The films shall be allowed to cure at room temperature for at least 72 hours before testing.
- (k) When tested according to ASTM D 638, the epoxy pavement marking materials shall have a tensile strength of not less than 6,000 psi (41,300 kPa). The Type IV specimens shall be cast in a suitable mold not more than 1/4 in. (6.3 mm) thick and pulled at a rate of 1/4 in./min (6.3 mm/min) by a suitable dynamic testing machine. The samples shall be allowed to cure at room temperature for at least 72 hours before testing.

- (l) When tested according to ASTM D 695, the catalyzed epoxy pavement marking materials shall have a compressive strength of not less than 12,000 psi (83,000 kPa). The cast sample shall be conditioned at room temperature for a minimum of 72 hours before performing the indicated tests. The rate of compression of these samples shall 1/4 in./min (6.3 mm/min) or less.
- (m) The glass beads shall meet the requirements of Article 1095.07 and the following.
 - (1) The first drop glass beads shall be tested by the standard visual method of large glass spheres adopted by the Department. The first drop glass shall contain a minimum of 63 percent silica (SiO_2). The beads shall have a silane coating and meet the following sieve requirements.

U.S. Standard Sieve Number	Sieve Size	% Passing (By Weight)
12	1.70 mm	95-100
14	1.40 mm	75-95
16	1.18 mm	10-47
18	1.00 mm	0-7
20	850 μm	0-5

- (2) The second drop glass beads shall be Type B.
- (3) The glass beads shall have a silane coating.
- (n) The epoxy paint shall be applied to an aluminum alloy panel (Federal Test Std. No. 141, Method 2013) at a film thickness of 14 to 16 mils (0.35 to 0.41 mm) and allowed to cure for 72 hours at room temperature. Subject the coated panel for 75 hours to accelerated weathering using the light and water exposure apparatus (fluorescent UV - condensation type) as specified in ASTM G 53 (equipped with UVB-313 lamps).

The cycle shall consist of four hours UV exposure at 122 °F (50 °C) followed by four hours of condensation at 104 °F (40 °C). UVB 313 bulbs shall be used. At the end of the exposure period, the panel shall show no more than 10 Hunter Lab Delta E units or substantial change in gloss from the original, non-exposed paint.
- (o) The material shall be shipped to the jobsite in substantial containers and shall be plainly marked with the manufacturer's name and address, the name and color of the material, date of manufacture, and batch number.
- (p) Prior to approval and use of the epoxy pavement marking materials, the manufacturer shall submit a notarized certification from an independent laboratory, together with the results of all tests, stating these materials meet the requirements as set forth herein. The certified test report shall state the lot tested, manufacturer's name, brand name of epoxy and date of manufacture. The certification shall be accompanied by 1 pt (1/2 L) samples each of Part A and Part B. After approval by the Department, certification by

the epoxy manufacturer shall be submitted for each batch used. New independent laboratory certified test results and samples for testing by the Department shall be submitted any time the manufacturing process or paint formulation is changed. All costs of testing (other than tests conducted by the Department) shall be borne by the manufacturer.

- (q) Acceptance samples, shall consist of two 1 pt (1/2 L) samples of Part A and one 1 pt (1/2 L) sample of Part B, of each lot of paint. The samples shall be submitted to the Department for testing, together with a manufacturer's certification. The certification shall state the formulation for the lot represented is essentially identical to that used for qualification testing. All acceptance samples shall be taken by a representative of the Illinois Department of Transportation. The epoxy pavement marking materials shall not be used until tests are completed and they have met the requirements as set forth herein.

1095.05 Preformed Thermoplastic Pavement Marking. All materials shall be according to Article 1095.01 and the following.

- (a) The preformed thermoplastic pavement marking film shall consist of resin, aggregates, pigments, binders and glass beads which have been factory produced as a finished product supplied in a preformed state.
- (b) Glass beads shall be uniformly distributed throughout the entire cross sectional area. Immediate retroreflectivity can be provided by a preapplied layer of beads or by scattering surface beads on a molten material during application. The bead adhesion shall be such that beads are not easily removed when the material surface is scratched with a thumbnail.
- (c) The pavement markings shall contain a minimum of 30 percent graded glass beads by weight. The beads shall be clear and transparent and free of pits and scratches. Not more than 20 percent shall consist of irregular, fused spheroids, or silica. The index of refraction shall be not less than 1.50 when tested using the liquid immersion method.
- (d) The pavement markings shall have a minimum thickness of 125 mils (3.15 mm) as supplied by the manufacturer.
- (e) The pavement markings shall be capable of conforming to pavement contours, breaks, and faults through the action of traffic at normal pavement temperatures. The markings shall have resealing characteristics and shall be capable of fusing with itself and previously applied thermoplastic when heated with a propane blowtorch.
- (f) The pavement markings shall be resistant to deterioration due to the exposure to sunlight, water, oil, gasoline, salt or adverse weather conditions.
- (g) The preformed thermoplastic markings shall not be brittle and must be sufficiently cohesive and flexible at temperatures exceeding 50 °F (10 °C) for one person to carry without the danger of fracturing the material prior to application.

- (h) The surface of the preformed thermoplastic markings shall provide a minimum skid resistance value of 45 BPN when tested according to ASTM E 303-74.
- (i) The preformed thermoplastic marking material shall have flexibility at 85 degrees such that when a 2 1/2 x 6 in. (63 x 150 mm) sample is bent through an arc at 90 degrees at a uniform rate in ten seconds (9 degrees/second) over a 1 in. (25 mm) mandrel, no cracking occurs in the test sample. The sample must be conditioned prior to testing at $85 \pm 2^{\circ}\text{F}$ ($29 \pm 1^{\circ}\text{C}$) for a minimum of four hours. At least two specimens tested must meet the flexibility requirements at 85°F (29°C) for a passing result.
- (j) Identification. The material shipped to the job site shall be identified by the same shipment number(s), if applicable, batch or lot number(s), as the sample(s) tested and approved for that job. The batch or lot number(s) of the material, and the month and year the material is packaged, shall be stenciled or embossed on the container or included on the label.
- (k) Sampling and testing. All material samples for acceptance tests will be taken or witnessed by a representative of the Bureau of Materials and Physical Research, 126 East Ash Street, Springfield, Illinois 62704-4766. Random check samples may be taken at the job site at the discretion of the Engineer.

The Engineer will test and certify the basic requirements.

The Contractor shall provide the Engineer certification from the manufacturer that the material to be furnished meets all the requirements of these specifications.

Sample(s) of preformed plastic shall be a minimum 2 sq ft (0.18 sq m) of each color to be used.

The sample(s) shall be labeled with the shipment number(s), if applicable, batch or lot number(s), all batch number(s) comprising a lot, date, quantity and any other pertinent information.

1095.06 Pavement Marking Tape. White or yellow marking tape shall consist of glass spheres of high optical quality embedded into a binder on a suitable backing that is precoated with a pressure sensitive adhesive. The spheres shall be of uniform gradation and distributed evenly over the surface of the tape.

The material shall be white or yellow as specified. The colors shall conform closely to Federal color tolerances for pavement marking paint.

The white and yellow tape shall be readily visible when viewed under automotive headlights at night. Reflective values, measured in accordance with the photometric testing procedure of ASTM D 4061 shall not be less than those listed in the table below. The Coefficient of Retroreflected Luminance R_L , shall be expressed as average millicandelas/foot candle/sq ft (millicandelas/lux/sq m), measured on a 2 x 1 ft (600 x 300 mm) panel at 86 degree entrance angle.

Coefficient of Retroreflected Luminance					
Type I			Type III		
Observation Angle	White	Yellow	Observation Angle	White	Yellow
0.2°	2700	2400	0.2°	1300	1200
0.5°	2250	2000	0.5°	1100	1000

The pavement marking tape shall have a precoated pressure sensitive adhesive and shall require no activation procedures. Test pieces of the tape shall be applied according to the manufacturer's instructions and tested according to ASTM D 1000, Method A, except that a stiff, short bristle roller brush and heavy hand pressure will be substituted for the weighted rubber roller in applying the test pieces to the metal test panel. Material tested as directed above shall show a minimum adhesion value of 750 g/in. (30 g/mm) width at the temperatures specified in ASTM D 1000. The adhesive shall be resistant to oils, acids, solvents, and water, and shall not leave objectionable stains or residue after removal. The material shall be flexible and conformable to the texture of the pavement.

Type III tape shall be capable of performing for the duration of a normal construction season and shall then be capable of being removed intact or in large sections at pavement temperatures above 40 °F (4 °C) either manually or with a roll-up device without the use of sandblasting, solvents, or grinding. The Contractor shall provide the Engineer certification, from the manufacturer of the Type III tape, that the material to be furnished meets the requirements for being removed after the following minimum traffic exposure based on transverse test decks with rolling traffic.

- (a) Time in place - 400 days
- (b) ADT per lane - 9,000 (28 percent trucks)
- (c) Axle hits - 10,000,000 minimum

Samples of the material, applied to standard specimen plates will be measured for thickness, and tested for durability in accordance with Federal Test Method Standard No. 141A, Method 6192, using a CS-17 wheel and 1000-gram load, and shall meet the following criteria for minimum initial thickness and for durability, showing no significant change in color after being tested for the number of cycles indicated.

Test	Type I		Type III	
	White	Yellow	White	Yellow
Initial Thickness mils (mm)	20 (0.51)	20 (0.51)	20 (0.51)	20 (0.51)
Durability (Cycles)	5,000	5,000	1,500	1,500

The pavement marking tape, when applied according to the manufacturer's recommended procedures, shall be weather resistant and shall show no appreciable fading, lifting, or shrinkage during the useful life of the marking. The tape, as applied, shall be of good appearance, free of cracks, and edges shall be true, straight, and unbroken.

1095.07 Glass Beads for Pavement Markings. The glass beads used for reflectorizing pavement marking lines shall be Type A or Type B. Type A (uncoated)

is intended for use as drop-on beads with solvent-based pavement marking paints and as intermix beads with thermoplastic pavement marking materials. Type B (moisture resistant, silicone coated) is intended for use as drop-on beads with thermoplastic pavement marking materials and waterborne-type marking paints.

- (a) Properties. The glass beads furnished under this specification shall consist essentially of transparent, water-white glass particles of a spherical shape. They shall be manufactured from a glass of a composition designed to be highly resistant to traffic wear and to the effects of weathering. The glass beads shall be according to the following.

- (1) Sieve Analysis. The glass beads shall meet the following sieve requirements.

U. S. Standard Sieve No.	Sieve Sizes	Total Percent By Weight (Mass) Passing
20	850 μm	100
30	600 μm	75 – 100
50	300 μm	15 – 40
100	150 μm	0 – 5
200	75 μm	0 – 1

- (2) Imperfections. The surface of the glass beads shall be free of pits and scratches. The glass beads shall be spherical in shape and shall contain not more than 20 percent by weight of irregular shapes when tested by the standard method using a vibratile inclined glass plate as adopted by the Department.
- (3) Index of Refraction. The index of refraction of the glass beads shall not be less than 1.50 when tested by the immersion method at 77 °F (25 °C).
- (4) Silica Content. The glass beads shall contain not less than 70 percent silica (SiO_2).
- (5) Chemical Stability. Glass beads which show tendency toward decomposition, including surface etching, when exposed to paint or thermoplastic constituents shall be rejected. The glass beads shall be tested according to Federal Specification TT-B-1325B, Section 4.3.9 (water resistance) and evaluated for compliance with Section 3.2.9, with the following exceptions.

The size of sample to be tested shall be 25 grams and the reflux time shall be five hours.

- (6) Flowing Properties. The glass beads shall flow uniformly through dispensing equipment in atmospheric humidity up to 94 percent.
- a. Type A. The beads shall be free of silicones, waxes, oils, or other coatings and pass the following test.

One hundred grams of glass beads, spread evenly and thinly in a suitable container, shall be conditioned at 77 °F (25 °C) for four hours over a solution of sulfuric acid (Sp. Gr. 1.10) in a closed desiccator. After four hours, the glass beads shall flow readily through a clean glass analytical funnel, 60 degree, 3 in. (75 mm) diameter and 6 in. (150 mm) stem. Inside diameter of the stem shall be a nominal 1/4 in. (6.33 mm).

- b. Type B. The beads shall have a silicone, moisture resistant coating and pass the following test.

One hundred grams of beads are placed in a 600 ml beaker and an equivalent volume of distilled water shall be added to the beaker. The beaker will then stand for five minutes, at the end of which time the water shall be carefully poured off and the beads transferred to a clean dry beaker and allowed to stand for five minutes. The beads will then be poured slowly into a standard glass funnel (Corning 6120), 5 in. (127 mm) diameter, 4 in. (102 mm) stem length and 7/16 in. (11 mm) stem inside diameter. The beads shall flow through the funnel stem without stoppage. Slight initial agitation to start the flow through the funnel at the beginning of the test is permissible.

- (b) Packaging. The glass beads shall be packaged in approved moisture proof bags consisting of at least five ply paper construction unless otherwise specified. Each bag shall contain 50 lb (22.7 kg) net, and shall be legibly marked with the manufacturer, IDOT specification and type, lot number, and the month and year the glass beads were packaged. The letters and numbers used in the stencils shall be a minimum of 1/2 in. (12.7 mm) in height.
- (c) Sampling and Testing. Unless otherwise provided, all materials shall be sampled and tested in accordance with the latest published standard methods of the American Society for Testing and Materials, and revisions thereof, in effect on the date of the invitation for bids, where such standard methods exist. In case there are no ASTM Standards which apply, applicable standard methods of the American Association of State Highway and Transportation Officials, or the Federal Government, or of other recognized standardizing agencies shall be used.

The right is reserved to inspect the glass beads either at the place of manufacture or at the destination or at both places. If inspected at the place of manufacture, the manufacturer shall furnish such facilities as may be required for collecting and forwarding samples, and shall also furnish facilities for testing the glass beads during the process of manufacture, if required. During the manufacturing operations, the Department's representative shall have free entry at all times to such parts of the plant as concern the manufacture of the glass beads. Tests will be made by and at the expense of the Department unless otherwise specified.

All material samples for acceptance tests shall be taken or witnessed by a representative of the Bureau of Materials and Physical Research and shall be submitted to the Engineer of Materials and Physical Research, 126 East Ash Street, Springfield, Illinois 62704-4766.

1095.08 Polyurea Pavement Marking. Materials shall be according to the following.

- (a) **Polyurea Pavement Marking.** The polyurea pavement marking material shall consist of a 100 percent solid two-part system formulated and designed to provide a simple volumetric mixing ratio of two components (must be two or three volumes of Part A to one volume of Part B). No volatile or polluting solvents or fillers will be allowed.
- (b) **Pigmentation.** The pigment content by weight (mass) of component A shall be determined by low temperature ashing according to ASTM D 3723. The pigment content shall not vary more than \pm two percent from the pigment content of the original qualified paint.

White Pigment shall be Titanium Dioxide meeting ASTM D 476, Type II Rutile.

Yellow Pigment shall be Organic Yellow and contain no heavy metals.

- (c) **Environmental.** Upon heating to application temperature, the material shall not exude fumes which are toxic or injurious to persons or property.
- (d) **Daylight Reflectance.** The daylight directional reflectance of the cured polyurea material (without reflective media) shall be a minimum of 80 percent (white) and 50 percent (yellow) relative to magnesium oxide when tested using a color spectrophotometer with a 45 degree circumferential/zero degree geometry, illuminant C, and two degree observer angle. The color instrument shall measure the visible spectrum from 380 to 720 nm with a wavelength measurement interval and spectral bandpass of 10nm. In addition, the color of the yellow polyurea shall visually match Color Number 33538 of Federal Standard 595a with chromaticity limits as follows.

x	0.490	0.475	0.485	0.539
y	0.470	0.438	0.425	0.456

- (e) **Weathering Resistance.** The polyurea marking material, when mixed in the proper ratio and applied at 14 to 16 mils (0.35 to 0.40 mm) wet film thickness to an aluminum alloy panel (Federal Test Std. No 141, Method 2013) and allowed to cure for 72 hours at room temperature, shall be subjected to accelerated weathering for 75 hours. The accelerated weathering shall be completed by using the light and water exposure apparatus (fluorescent UV – condensation type) and tested according to ASTM G 53.

The cycle shall consist of four hours UV exposure at 122 °F (50 °C) and four hours of condensation at 104 °F (40 °C). UVB 313 bulbs shall be used. At

the end of the exposure period, the material shall show no substantial change in color or gloss.

- (f) Dry Time. The polyurea pavement marking material, when mixed in the proper ratio and applied at 14 to 16 mils (0.35 to 0.40 mm) wet film thickness and with the proper saturation of reflective media, shall exhibit a no-tracking time of ten minutes or less when tested according to ASTM D 711.
- (g) Adhesion. The catalyzed polyurea pavement marking materials when applied to a 4 x 4 x 2 in. (100 x 100 x 50 mm) concrete block shall have a degree of adhesion which results in a 100 percent concrete failure in the performance of this test.

The concrete block shall be brushed on one side and have a minimum strength of 3500 psi (24,100 kPa). A 2 in. (50 mm) square film of the mixed polyurea shall be applied to the brushed surface and allowed to cure for 72 hours at room temperature. A 2 in. (50 mm) square cube shall be affixed to the surface of the polyurea by means of an epoxy glue. After the glue has cured for 24 hours, the polyurea specimen shall be placed on a dynamic testing machine in such a fashion so that the specimen block is in a fixed position and the 2 in. (50 mm) cube (glued to the polyurea surface) is attached to the dynamometer head. Direct upward pressure shall be slowly applied until the polyurea system fails. The location of the break and the amount of concrete failure shall be recorded.

- (h) Hardness. The polyurea pavement marking materials when tested according to ASTM D 2240 shall have a shore D hardness of between 70 and 100. Films shall be cast on a rigid substrate at 14 to 16 mils (0.35 to 0.40 mm) in thickness and allowed to cure at room temperature for 72 hours before testing.
- (i) Abrasion. The abrasion resistance shall be evaluated according to ASTM D 4060 using a Taber Abrader with a 2.20-lb (1000-gram) load and CS 17 wheels. The duration of the test shall be 1000 cycles. The loss shall be calculated by difference and be less than 120 mgs. The tests shall be run on cured samples of polyurea material which have been applied at a film thickness of 14 to 16 mils (0.35 to 0.40 mm) to code S-16 stainless steel plates. The films shall be allowed to cure at room temperature for at least 72 hours and not more than 96 hours before testing.
- (j) Reflective Media. The reflective media shall meet the following requirements.
 - (1) Type I – The glass beads shall meet the requirements of Article 1095.07 and the following.
 - a. First Drop Beads. The first drop glass beads shall be tested by the standard visual method of large glass spheres adopted by the Department. The beads shall have a silane coating and meet the following sieve requirements.

U.S. Standard Sieve Number	Sieve Size	% Passing By Weight (Mass)
12	1.70 mm	95 – 100
14	1.40 mm	75 – 95
16	1.18 mm	10 – 47
18	1.00 mm	0 – 7
20	850 µm	0 – 5

- b. Second Drop Glass Beads. The second drop glass beads shall meet the requirements of Article 1095.07 for Type B.
- (2) Type II – The combination of microcrystalline ceramic elements and glass beads shall meet the following requirements.
- a. First Drop Glass Beads. The first drop glass beads shall meet the following requirements.
 1. Composition. The elements shall be composed of a titania opacified ceramic core having clear and or yellow tinted microcrystalline ceramic beads embedded to the outer surface.
 2. Index of Refraction. All microcrystalline reflective elements embedded to the outer surface shall have an index of refraction of 1.8 when tested by the immersion method.
 3. Acid Resistance. A sample of microcrystalline ceramic beads supplied by the manufacturer shall show resistance to corrosion of their surface after exposure to a one percent solution (by weight (mass)) of sulfuric acid. Adding 0.2 oz (5.7 ml) of concentrated acid into the water shall make the one percent acid solution. This test shall be performed by taking 1 x 2 in. (25 x 50 mm) sample and adhering it to the bottom of a glass tray and placing just enough acid solution to completely immerse the sample. The tray shall be covered with a piece of glass to prevent evaporation and allow the sample to be exposed for 24 hours under these conditions. The acid solution shall be decanted (do not rinse, touch, or otherwise disturb the bead surfaces) and the sample dried while adhered to the glass tray in a 150 °F (66 °C) oven for approximately 15 minutes. Microscope examination (20X) shall show no white (corroded) layer on the entire surface.
 - b. Second Drop Glass Beads. The second drop glass beads shall meet the requirements of Article 1095.07 for Type B or the following manufacturer's specification.
 1. Sieve Analysis. The glass beads shall meet the following requirements.

U.S. Standard Sieve Number	Sieve Size	% Passing By Weight (Mass)
20	850 μm	100
30	600 μm	75 – 95
50	300 μm	15 – 35
100	150 μm	0 – 5

The manufacturer of the glass beads shall certify that the treatment of the glass beads meets requirements of the polyurea manufacturer.

2. Imperfections. The surface of the glass beads shall be free of pits and scratches. The glass beads shall be spherical in shape and shall contain a maximum of 20 percent by weight (mass) of irregular shapes when tested by the standard method using a vibratile inclined glass plate as adopted by the Department.
 3. Index of Refraction. The index of refraction of the glass beads shall be a minimum of 1.50 when tested by the immersion method at 77 °F (25 °C).
- (k) Packaging. Microcrystalline ceramic reflective elements and glass beads shall be delivered in approved moisture proof bags or weather resistant bulk boxes. Each carton shall be legibly marked with the manufacturer, specifications and type, lot number, and the month and year the microcrystalline ceramic reflective elements and/or glass beads were packaged. The letters and numbers used in the stencils shall be a minimum of 1/2 in. (13 mm) in height.
- (1) Moisture Proof Bags. Moisture proof bags shall consist of at least five ply paper construction unless otherwise specified. Each bag shall contain 50 lb (22.7 kg) net.
 - (2) Bulk Weather Resistance Boxes. Bulk weather resistance boxes shall conform to Federal Specification PPP-8-640D Class II or latest revision. Boxes are to be weather resistant, triple wall, fluted, corrugated-fiber board. Cartons shall be strapped with two metal straps. Straps shall surround the outside perimeter of the carton. The first strap shall be located approximately 2 in. (50 mm) from the bottom of the carton and the second strap shall be placed approximately in the middle of the carton. All cartons shall be shrink wrapped for protection from moisture. Cartons shall be lined with a minimum 4 mil polyester bag and meet Interstate Commerce Commission requirements. Cartons shall be approximately 38 x 38 in. (1 x 1 m), contain 2000 lb (910 kg) of microcrystalline ceramic reflective elements and/or glass beads and be supported on a wooden pallet with fiber straps.
- (l) Packaging. The material shall be shipped to the job site in substantial containers and shall be plainly marked with the manufacturer's name and

address, the name and color of the material, date of manufacture, and batch number.

- (m) Verification. Prior to approval and use of the polyurea pavement marking materials, the manufacturer shall submit a notarized certification of an independent laboratory, together with the results of all tests, stating these materials meet the requirements as set forth herein. The certification test report shall state the lot tested, manufacturer's name, brand name of polyurea and date of manufacture. The certification shall be accompanied by one 1 pt (1/2 L) sample each of Part A and Part B. Samples shall be sent in the appropriate volumes for complete mixing of Part A and Part B.

After approval by the Department, certification by the polyurea manufacturer shall be submitted for each batch used. New independent laboratory certified test results and samples for testing by the Department shall be submitted any time the manufacturing process or paint formulation is changed. All costs of testing (other than tests conducted by the Department) shall be borne by the manufacturer.

- (n) Acceptance Samples. Acceptance samples shall consist of one 1 pt (1/2 L) sample of each Part A and Part B, of each lot of paint. Samples shall be sent in the appropriate volumes for complete mixing of Part A and Part B. The samples shall be submitted to the Department for testing, together with a manufacturer's certification. The certification shall state the formulation for the lot represented is essentially identical to that used for qualification testing. All acceptance samples will be taken by a representative of the Department. The polyurea pavement marking materials shall not be used until tests are completed and they have met the requirements as set forth herein.
- (o) Material Retainage. The manufacturer shall retain the test sample for a minimum of 18 months.

SECTION 1096. PAVEMENT MARKERS

1096.01 Raised Reflective Pavement Markers. Raised reflective pavement markers shall meet the following specifications.

- (a) The markers shall be low profile units consisting of an iron casting according to ASTM A 536-84, Grade 72-45-05 hardened to 52-54RC to which is attached a replaceable prismatic retroreflector for reflecting light from one or two directions as specified. The casting shall be shaped to deflect a snowplow blade upward, thus preventing damage to the reflectors. The bottom of the casting shall incorporate two parallel keels and a bow shaped web designed to fit into a grooved road surface. The casting shall have leveling tabs to ensure proper embedment and shall be fastened to the road surface using an epoxy adhesive. The casting shall be designed for bidirectional plowing. The casting shall be marked with the manufacturer's name and the model number of the marker shall be visible after installation.

- (b) The overall dimensions for raised reflective pavement markers shall be approximately 10 in. (254 mm) long by 5.5 in. (140 mm) wide and a maximum of 1.76 in. (45 mm) high. The overall dimensions for bridge raised reflective pavement markers shall be approximately 9.25 in. (235 mm) long by 5.86 in. (149 mm) wide and a maximum of 1.25 in. (32 mm) high. The surface of the keel and web shall be free of scale, dirt, rust, oil, grease, or any other contaminant which may reduce bond.
- (c) The reflector shall be of the prismatic type consisting of a methyl methacrylate or suitably compounded acrylonitrile butadiene styrene (ABS) shell filled with a mixture of an inert thermosetting compound and filler material. The exterior surface of the shell shall be smooth and contain one (monodirectional) or two (bidirectional) methyl methacrylate prismatic reflector faces of the colors specified. The shell shall be fabricated in a manner that will provide a mechanical interlock between the thermosetting compound and the shell. The thermosetting compound shall bond directly to the backside of the metalized lens surface. The manufacturer's trademark shall be molded in the face of the reflector lens or on the reflector body so as to be visible after installation.
- (d) The reflector lens shall be high-intensive type corner cube prismatic and shall provide total internal reflection of the light entering the lens face. The reflector shall be 4 in. (100 mm) long x 2 in. (50 mm) wide x 0.44 in. (11 mm) high and fit securely into a recessed area on the upper surface of the marker casting web. The reflective surface shall be a minimum of 1.6 sq in. (1,030 sq mm) in area. The reflector shall have an abrasion resistant reflective surface.
- (e) The specific intensity of the reflective surface at 0.2 degrees divergence angle shall be as follows when the incident light is parallel to the base of the marker.

Minimum Specific Intensity (candelas/foot candle (candelas/lux))						
Entrance Angle	Crystal		Amber		Red	
	0°	20°	0°	20°	0°	20°
Observation Angle	0.2°	0.2°	0.2°	0.2°	0.2°	0.2°
Specific Luminance	3.0 (0.28)	1.2 (0.11)	1.8 (0.16)	0.7 (0.07)	0.7 (0.07)	0.3 (0.03)

The marker color(s) shall be as specified in the plans.

1096.02 Temporary Raised Reflective Pavement Markers. Temporary raised reflective pavement markers shall be according to the following.

- (a) The marker shall be of the prismatic type consisting of a methyl methacrylate or acrylonitrile butadiene styrene (ABS) shell. The exterior surface of the marker shall be smooth and contain one (monodirectional) or two (bidirectional) methyl methacrylate cube corner prismatic reflector faces of the color specified. The cube corner prismatic reflectors shall either be molded within the marker or sonically sealed to the face of the shell. The manufacturer's trademark shall be molded either in the face of the reflector lens or on the shell so it is visible after installation.

- (b) The marker shall have a maximum height of 3/4 in. (19 mm), either rectangular or octagonal in shape and a minimum 4 x 3 in. (100 x 75 mm) overall. The base of the marker shall be flat. The reflector face shall slope from the base toward the top of the marker. The reflective area of each face shall be a minimum of 0.35 sq in. (225 sq mm) and may be divided into no more than three separate segments.
- (c) The markers, without an adhesive pad, shall support a load of 1,000 lb (450 kg). This shall be determined by centering a marker over the open end of a vertically-positioned hollow metal cylinder. The cylinder shall be 1 in. (25 mm) in height and have an internal diameter of 3 in. (75 mm) and a wall thickness of 0.25 in. (6.3 mm). The load shall be applied slowly to the top of the marker through a 1 in. (25 mm) diameter x 1 in. (25 mm) high metal rod centered on top of the marker. Breakage or significant deformation of the marker shall constitute failure.
- (d) The marker shall have a finish and color that will not fade in ultraviolet conditions or be conducive to tire tracking and will provide good daytime delineation. The specific intensity of the reflective surface at 0.2 degrees divergence angle shall be as follows when the incident light is parallel to the base of the marker.

Minimum Specific Intensity (candelas/foot candle (candelas/lux))		
Color	Incidence Angle	
	0°	20°
Crystal	1.0 (0.09)	0.4 (0.04)
Amber	0.6 (0.06)	0.2 (0.02)

The marker color(s) shall be as specified in the plans.

SECTION 1097. REFLECTORS

1097.01 General. The reflectors shall be molded of acrylic plastic into a rectangular or trapezoidal shape designed to transmit a light pattern back toward the light source.

Reflectors shall be constructed of methyl methacrylate (acrylic) plastic and shall have a smooth face free of cracks and checks. The reflectors shall be the color specified in the plans and shall be ready for mounting. The manufacturer's trademark shall be molded in the face of the reflector lens or on the reflector body so it is visible after installation.

1097.02 Prismatic Barrier Reflectors. The unit shall have a minimum of 9.0 sq in. (5800 sq mm) of effective reflective area.

Reflectors shall be according to the following minimum specific intensities using the average values of three reflectors for each color.

Minimum Specific Intensity (candelas/foot candle (candelas/lux))			
Color	Incidence Angle		
	0°	20°	35°
Crystal	60 (5.6)	55 (5.1)	9 (0.8)
Amber	36 (3.3)	33 (3.1)	5 (0.5)

1097.03 Reflectors for Delineators. The Contractor shall furnish, when requested to do so, a certification from the manufacturer stating that all reflectors conform to these requirements. The reflectors shall be furnished in either amber or crystal as specified and shall be ready for mounting. The plastic reflector units shall be free of cracks and checks, and fabrication shall be accomplished in a uniform and professional manner.

The reflectors shall be molded of methylmethacrylate plastic and have a clear, smooth and transparent lens (face) with a central mounting hole. The lens shall have a reflective area of not less than 6.5 sq in. (4150 sq mm) nor more than 12.0 sq in. (7750 sq mm) and shall be circular in shape. The manufacturer's trademark shall be molded in the face of the lens.

The rear surface of the lens shall provide reflectivity by a prismatic configuration such that it will affect total retrodirective internal reflection of light incident to the lens surface without the necessity of any plating or separate reflector.

The rear reflective surface of the lens shall be protected by a plastic coated metallic foil back or a separate plastic back fused to the lens under heat and pressure around the entire perimeter and the central mounting hole to form a unit permanently sealed against dust, water, and water vapor.

- (a) Intensity. The coefficient of luminous intensity of each reflector shall be equal to or exceed the following minimum values regardless of reflector orientation.

Divergence Angle	Entrance Angle	Intensity Candle Power per Foot Candle (candelas/lux)	
		Crystal	Amber
0.2°	0°	119 (11.0)	71 (6.6)
0.2°	20°	47 (4.4)	28 (2.6)

- (b) Sealing. Submerge five reflectors in a water bath at room temperature. Subject the submerged samples to a vacuum of 5 in. (125 mm) gage for five minutes. Restore atmospheric pressure and leave the samples submerged for five minutes. The samples shall show no evidence of water intake.

- (c) Heat Resistance. Place three reflectors in a circulating air oven for four hours at $175 \pm 5^{\circ}\text{F}$ ($80 \pm 3^{\circ}\text{C}$). The reflectors shall be placed in a horizontal position on a grid or perforated shelf permitting free air circulation. At the conclusion of the test, the samples shall be removed from the oven and permitted to cool in air to room temperature. The samples shall show no significant change in shape and general appearance when compared with unexposed control standards.
- (d) Housings. One of the following types of housings shall be used.
- (1) Type A. The back side of the reflector shall be protected by a plastic back fused to the lens under heat and pressure around the entire perimeter and the center mounting hole. The center mounting hole shall have an inside diameter of 3/16 in. (5 mm).
 - (2) Type B. The back side of the reflector shall be protected by a plastic coated metallic foil back, and be housed in 0.020 in. (0.5 mm) aluminum, formed to retain the reflector. The housing shall be provided with four embossed circular reinforcement ribs. An aluminum grommet with a 3/16 in. (5 mm) inside diameter shall be expanded within the reflector mounting hole.

1097.04 Prismatic Curb Reflectors. The unit shall provide a reflective area between 1 1/2 sq in. (960 sq mm) and 2 sq in. (1290 sq mm). The base of the marker shall be designed for adhesive mounting.

The unit shall support an 800 lb (360 kg) load. This shall be determined by placing the unit on a flat plate and slowly applying the load by means of another plate evenly to the entire top flat surface of the unit. Breakage or significant deformation of the unit shall constitute failure.

The coefficient of luminous intensity of each reflector shall be equal to or exceed the following minimum values regardless of reflector orientation.

Divergence Angle	Entrance Angle	Intensity Candle Power per Foot Candle (candelas/lux)	
		Crystal	Amber
0.2°	0°	14 (1.3)	11 (1.0)
0.2°	+5° *	14 (1.3)	11 (1.0)
0.2°	+10° *	9 (0.8)	7 (0.7)
0.2°	+20° *	5 (0.5)	7 (0.4)

* Traffic side

DIVISION 1100. EQUIPMENT**SECTION 1101. GENERAL EQUIPMENT**

All equipment utilized in the removal of roadway surfaces or waterproofing membranes shall meet, and shall be operated in compliance with a visual emission limitation of 30 percent opacity or Ringleman 1 for a period not longer than one minute and for not more than four minutes in the aggregate in any 60 minute period.

1101.01 Rollers. No roller shall be used that has in any way been thrown out of its original balance by the application of attachments not approved by the Engineer. All bearings shall be tight.

- (a) **Pneumatic-Tired Rollers.** The roller shall consist of not less than nine pneumatic tires revolving on two axles. The tires on the front and rear wheels shall be staggered so that they will cover the entire area over which the roller travels. Under working conditions, the roller shall develop a compression of not less than 225 lb/in. (40 N/mm) width of tire tread.
- (b) **Heavy Pneumatic-Tired Rollers.** The roller shall have a gross weight (mass) of not less than 25 tons (23 metric tons) and shall consist of not less than four pneumatic-tired wheels revolving in one transverse line. The width of the roller shall be not less than 8 ft (2.4 m), and it shall be constructed in two or more sections in such a manner that each section is free to oscillate or move independently. Under working conditions, the roller shall develop a compression of not less than 650 lb/in. (114 N/mm) width of tire tread.
- (c) **Self-Propelled Pneumatic-Tired Roller.** The roller shall be of the oscillating wheel type consisting of not less than seven pneumatic-tired wheels revolving on two axles, and capable of being ballasted to the weight (mass) required. The tires on the front and rear wheels shall be staggered so that the tire sidewalls will have a minimum overlap of 1/2 in. (13 mm). The roller shall provide for a smooth operation when starting, stopping or reversing direction.

The tires shall withstand inflation pressures between 60 and 120 psi (415 and 825 kPa). The roller shall be equipped with an adequate scraping or cleaning device on each tire to prevent the accumulation of material on the tires. When used for the compaction of hot-mix asphalt, the roller shall be equipped with a water system which will keep all tires uniformly wet to prevent material pickup.

The Contractor shall provide means for determining the weight (mass) of the roller as distributed on each wheel. Ballast shall be included in determining the weight (mass).

- (d) **Tamping Rollers.** The roller shall have a minimum weight (mass) of 90 lb/in. (16 N/mm) width of drum, and each individual tamper shall develop a compression of not less than 100 psi (690 kPa) of its tamping face area. The width of the tamping roller shall be not less than 8 ft (2.4 m), and it shall be constructed in two or more sections in such a manner that each section is

free to oscillate or move independently. It shall be equipped with cleaning teeth at the rear.

- (e) **Steel Wheel Rollers.** The roller shall be self-propelled and provide a smooth operation when starting, stopping, or reversing directions. The steering mechanism shall provide for positive control of the roller. Roller wheels shall be smooth and free from openings or projections which will mar the surface on which the roller is operated. Motor rollers shall be equipped with drip pans to contain oil, grease, or gasoline drips generated by the roller operation. The roller shall be provided with adjustable scrapers which shall be used when necessary to keep the surface of the wheels clean.

When used on a hot-mix asphalt surface, the roller shall be equipped with water tanks and sprinkling devices which shall be used to wet the wheels and prevent material pickup.

- (1) **Tandem Rollers.** The Contractor shall provide means for determining the weight (mass) of the roller as distributed on each axle. Ballast shall be included in determining the weight (mass).

The rear wheel may be crowned at the rate of not more than 3/16 in. in 4 1/2 ft (5 mm in 1.4 m). The front wheel shall be divided into at least two sections and shall show no noticeable crown. The weight (mass) of the roller shall meet requirements of the specific item of work being constructed.

- (2) **Three-Wheel Rollers.** The rear wheels of three-wheel rollers may be crowned at the rate of not more than 1/16 in. in 20 in. (2 mm in 500 mm) and shall be propelled with a differential gear. The front wheel shall be divided into at least two sections, shall show no noticeable crown, and shall overlap the compression area of each rear wheel by not less than 1 1/2 in. (38 mm). The weight (mass) of the roller shall meet requirements of the specific item of work being constructed.

- (f) **Trench Roller.** The roller shall be self-propelled, and provide a smooth operation when starting, stopping or reversing directions. The width of the compaction roller shall be not less than 20 in. (500 mm). The diameter of the compaction roller shall be not less than 60 in. (1500 mm). The roller wheels shall be smooth and free from openings or projections which will mar the surface on which the roller is operated. Motor rollers shall be equipped with drip pans to contain oil, grease or gasoline generated by the roller operation. The roller shall be provided with adjustable scrapers which shall be used when necessary to keep the surface of the wheels clean.

When used on a hot-mix asphalt (HMA) surface, the roller shall be equipped with water tanks and sprinkling devices which shall be used to wet the wheels and prevent material pickup.

The weight (mass) of the roller shall meet requirements of the specific item of work being constructed. The Contractor shall provide means for determining the weight (mass) of the roller as distributed on the compression wheel. Ballast shall be included in determining the weight (mass).

The balance wheel of the roller shall be adjustable in height to provide the slope of the surface of the specific item of work being constructed.

- (g) **Vibratory Roller.** The vibratory roller shall be self-propelled and provide a smooth operation when starting, stopping or reversing directions. The vibrating drum(s) amplitude and frequency shall be approximately the same in each direction and meet the following minimum requirements: drum diameter 48 in. (1200 mm), length of drum 66 in. (1650 mm), vibrators 1600 vibrations per minute (VPM), unit static force on vibrating drum(s) 125 lb/in. (22 N/mm), total applied force 325 lb/in. (57 N/mm), adjustable eccentrics, and reversible eccentrics on nondriven drum(s). The total applied force for various combinations of VPM and eccentric positions shall be shown on decals on the vibrating roller or on a chart maintained with the roller. The vibratory roller shall be equipped with water tanks and sprinkling devices, or other approved methods, which shall be used to wet the wheels to prevent material pickup.

A vibrating reed tachometer (hand type) shall be furnished with each vibratory roller. The vibrating reed tachometer shall have a range of 1000 to 4000 VPM. The vibrating reed tachometer shall have two rows of reeds, one ranging from 1000 to 2000 VPM and the other from 2000 to 4000 VPM.

1101.02 Disk Harrow. The disk harrow shall be the tandem type and shall meet the approval of the Engineer prior to its use.

1101.03 Mechanical Sweeper. The sweeper shall permit the revolutions of the broom to be adjusted in relation to its progression and permit the adjustment of the broom in relation to the surface being cleaned. It shall be supplied with sufficient extra or repair parts to prevent delay. The broom bristles shall be stiff enough to sweep clean without cutting into the surface. A broom with steel bristles will not be permitted.

1101.04 Reserved.

1101.05 Motor Grader. The motor grader shall be self-powered and equipped with an adjustable mold board. The cutting blade shall be straight and in good condition. There shall be a minimum of play in the blade operating mechanism.

1101.06 Rotary Speed Mixer. Rotary speed mixers shall be either the power takeoff or the self-powered type, equipped with a hydraulic lift. Worn scarifying and mixing parts shall be replaced and extra parts shall be available for replacement.

1101.07 Traveling Mixing Plant. All traveling mixing plants shall meet the approval of the Engineer. The plants shall be either the type which will pulverize the material to be treated and mix the material and cement with the proper amount of water without picking the materials up from the roadway, or the pugmill type which elevates the material into a pugmill for mixing. The plant shall be equipped with a device which will accurately control and measure the quantity of water used. Worn scarifying and mixing parts shall be replaced and extra parts shall be available for replacements.

1101.08 Seeding Equipment. Seeding equipment shall be according to the following.

- (a) Disk. The disk shall meet the approval of the Engineer and have sound unbroken blades, which have a minimum diameter of 15 in. (375 mm). The disk shall be weighted, if necessary, to obtain the required tillage depth of 3 in. (75 mm).
- (b) Slope Harrow. Slope harrows shall consist of a rolling weight (mass) attached by heavy chain to a tractor. The chain shall be of a suitable length, shall have picks welded to the links, and shall have a means of rotating the picks as the rolling weight (mass) is pulled in a direction parallel to the movement of the tractor.
- (c) Hydraulic Seeder. When hydraulic seeders are used, the inoculant and seed required shall be applied in a single operation.

Hydraulic seeding equipment shall include a pump rated and operated at no less than 100 gal/min (375 L/min) and no less than 100 psi (690 kPa) pressure. The tank shall have a mechanical agitator powerful enough to keep the seed and fertilizer in a uniform suspension in the water.

- (d) Cultipacker. The roller or cultipacker shall have rollers at least 12 in. (300 mm) in diameter and shall be of sufficient weight (mass) to pulverize the clods of soil. A double gang style shall be used.
- (e) Broadcast Seeders. Broadcast seeders may be hand held, tractor drawn, or tractor mounted. The seed shall drop through an adjustable flow regulator onto a rotating, horizontal disk or fan.
- (f) Tractor Drawn or Tractor Mounted Drop Seeders. These seeders shall be pulled by mechanical means, have an adjustable gate opening providing uniform flow of width adapted to the work, and drop the seed directly into place on the prepared seedbed. The seeder may be of a type mounted on cultipacker rollers which covers the seed and rolls the seedbed in one operation.
- (g) Rangeland Type Grass Drill and Interseeding Attachment. These seeders shall be designed specifically for the seeding of native prairie grasses and shall be approved by the Engineer prior to use. When seeding over existing turf, the rangeland type grass drill shall be equipped with a no-till interseeding attachment that is capable of cutting a slit in the soil free of leaves and debris, placing the seed in the slit, and compacting the seed into the soil of the slit.
- (h) Slit Seeder. These seeders shall be self-propelled or tractor-drawn and shall be designed specifically for no-till interseeding of turf grass seed into existing turf. The slit seeder shall be capable of performing the operations specified above in Article 1101.08(g).

1101.09 Membrane Curing Equipment. Membrane curing equipment shall be as follows.

- (a) Equipment for applying membrane curing shall meet the following requirements when the pavement width is 10 ft (3 m) or more. For lesser widths and for variable width pavement, the equipment shall meet the requirements of Article 1101.09(b). For the application of membrane curing compound, the mechanical equipment shall be self-propelled and shall be operated upon the pavement forms or, when a slip-form paver is used, upon the subgrade immediately adjacent to the edges of the pavement. The spraying equipment shall consist of a container having a capacity of not less than 25 gal (95 L) in which a constant pressure can be maintained by mechanical means, or a suitable pumping arrangement in order that a constant pressure at the spray nozzles will be maintained so that the membrane curing compound will be applied uniformly at the specified rate. The spray unit shall be rigidly attached and shall be equipped with mechanical devices providing constant agitation of the membrane curing compound and continuous circulation of the compound between the container and the spray nozzles. The spray nozzles shall be attached to a distributor pipe so the spray will be applied vertically from not more than 2 ft (600 mm) above the surface of the pavement, and their horizontal spacing shall be such that uniform coverage of the pavement surface will be obtained. The nozzles shall be designed so they will deliver a uniform fine spray and so that they can be easily cleaned. A suitable shield or apron shall be provided to effectively protect the spray from wind. Sufficient nozzles shall be on hand at all times so that any inefficient nozzle can be immediately replaced. Suitable means of cleaning and repairing nozzles shall also be on hand and shall be considered as being part of the spraying equipment.
- (b) The equipment used to apply membrane curing compound to variable widths of pavement and other concrete construction where permitted, may be equipped with a container having not less than 5 gal (20 L) in which a constant pressure shall be maintained by a mechanical means.
- (c) The equipment used to apply membrane curing compound to pavement widening shall meet the requirements of paragraph (a), except the equipment as a whole shall be mounted on a vehicle traveling on the existing pavement.

1101.10 Pavement Surface Test Equipment. Pavement surface test equipment shall be as follows.

- (a) 16 ft (5 m) Straightedge. The 16 ft (5 m) straightedge shall consist of a metal I-beam mounted between two wheels spaced 16 ft (5 m) between the axles. Scratcher bolts which can be easily and accurately adjusted, shall be set at the 1/4, 1/2, and 3/4 points between the axle. A handle suitable for pushing and guiding shall be attached to the straightedge. The straightedge shall meet the approval of the Engineer.
- (b) California Profilograph. The California profilograph or approved equivalent shall consist of a frame 25 ft (7.5 m) in length supported upon multiple

wheels at either end. The profile shall be recorded from the vertical movement of a wheel attached to the frame at mid point. The profile shall be recorded on a scale of 1:300 horizontally and 1:1 vertically. The profilograph shall be available to the Engineer before paving operations commence, be in working order ready to operate at time of delivery, and meet the following requirements.

- (1) The profile wheel shall not be out of round or excessively worn.
- (2) No frame alignment pins shall be missing and there shall be no appreciable movement of frame joints.
- (3) The carriage wheels shall not be excessively worn.
- (4) The steering rods shall be straight and all joints shall be tight when assembled.
- (5) The rear wheels shall track the front wheels within 6 in. (150 mm).
- (6) The horizontal scale on the profile shall check within 2 ft (600 mm) in 100 ft (30 m) (minimum calibration length shall be 200 ft (60 m). The vertical scale shall be true scale.
- (7) An adequate supply of recorder pens and profile paper for the type of recorder unit furnished shall be provided.
- (8) A reference marker shall be provided for guiding the profilograph along the profile lines 3 ft (1 m) from and parallel to the edge of pavement. The reference marker shall be reversible.

1101.11 Hydrodemolition Equipment. The equipment shall consist of filtering and pumping units operating with a remote controlled robotic device. The equipment shall be capable of removing concrete to the specified depth and of removing rust and concrete particles from exposed reinforcing bars.

1101.12 Water Blaster with Vacuum Recovery. The water blaster shall remove the stripe from the pavement using a high pressurized water spray with a vacuum recovery system to provide a clean, almost dry surface, without the use of a secondary cleanup process. The removal shall be to the satisfaction of the Engineer. The equipment shall contain a storage system that allows for the storage of the wastewater while retaining the debris. The operator shall be in immediate control of the blast head.

1101.13 Portable Shot Blast Equipment. The portable shotblast equipment shall use recyclable steel shot as an abrasive and shall include a dust collection system to provide dust free operation. Equipment shall utilize moisture and oil traps, in working order, of sufficient capacity to remove contaminants from the air and prevent oil or other contaminants from being deposited on the roadway surface. The equipment shall have an adequate air-cooled power source with a heavy duty hydrostatic transmission for variable speed operation, a variable abrasive valve for controlling the depth of cut, a small turning radius for maneuverability and a single switch one-man operation with forward and reverse capabilities. The equipment shall

have an operating speed range of 0 to 160 ft/min (0 to 50 m/min) and a forward and reverse travel speed range of 0 to 350 ft/min (0 to 105 m/min). The shot feed rate shall be variable from 0 to 700 lb/min (0 to 320 kg/min) and the shot hopper shall have a capacity of 200 lb (90 kg).

1101.14 Skid Steer Loader Equipped with a Hydraulic Hammer. The skid steer loader shall be wheel mounted and hydraulically actuated, with a maximum horsepower rating of 60 hp (45 kW) and a maximum total machine weight (mass) of 6600 lb (3000 kg). The hydraulic hammer shall have a maximum impact energy of 300 ft lb (410 J) and a maximum total weight (mass) of 475 lb (215 kg). The hydraulic hammer shall be attached to the skid steer loader in such a manner that the angle of attack of the hammer is fixed while breaking concrete.

1101.15 Self-Propelled Planing Machine. The planing machine shall have a wheel base width of not less than 10 ft (3 m) and shall be capable of heating, and planing the existing surface and depositing the material into a windrow in one or more passes.

1101.16 Self-Propelled Milling Machine. Self-propelled milling machines shall be according to the following.

- (a) Hot-Mix Asphalt (HMA) Surface Removal. The milling machine shall be capable of cold milling and cutting the existing HMA surface and depositing the cuttings into a windrow or directly loading the cuttings into a truck. It shall be capable of removing a lift of HMA at least 6 ft (1.8 m) in width and 1 1/2 in. (40 mm) in depth in a single pass. When the width of surface removal is less than 6 ft (1.8 m), machines less than 6 ft (1.8 m) wide will be permitted, except that the area milled shall not be wider than the width of the work specified on the plans. The milling machine shall be capable of accurately and automatically establishing profile grades by reference from either the existing pavement or from an independent grade control to provide a milled surface within a tolerance of 3/16 in. in 16 ft (5 mm in 5 m) when tested with a 16 ft (5 m) straightedge. It also shall have an effective means for removing all loose and excess material from the surface and for preventing any dust resulting from the operation from escaping into the air.
- (b) Median Removal Partial Depth. The milling machine shall be self-propelled and capable of removing the portland cement concrete by a cold milling process utilizing tungsten carbide cutting teeth. The equipment shall be capable of accurately controlling the elevation and cross slope of the removal, and shall have an effective means of removing the material from the median and of preventing dust from escaping into the air.

1101.17 Asphalt-Rubber Processor/Distributor. Equipment utilized in processing and applying asphalt-rubber shall be a truck or trailer mounted self-powered distributor equipped with a heating unit, a mixing unit capable of producing a homogenous mixture of asphalt and rubber, pump(s) capable of spraying asphalt-rubber within ± 0.05 gal/sq yd (± 0.23 L/sq m) of the specified rate, and a fully circulating spray bar capable of applying asphalt-rubber without a streaked or otherwise irregular pattern.

The distributor shall include a tachometer, pressure gauges, volume measuring devices, an onboard weighing device to aid in proportioning materials, and a thermometer. A "bootman" shall accompany the distributor and ride in a position so that all spray bar nozzles are in his/her full view and readily accessible for unplugging.

1101.18 Mechanical Laydown Equipment. The equipment shall handle full rolls of fabric and shall be capable of laying the fabric smoothly without excessive wrinkles or folds. Stiff bristle brooms to smooth the fabric and scissors to cut the fabric shall be provided with the equipment.

SECTION 1102. HOT-MIX ASPHALT EQUIPMENT

1102.01 Hot-Mix Asphalt Plant. The hot-mix asphalt (HMA) plant shall be the batch-type, continuous-type, or dryer drum plant. The plants shall be evaluated for prequalification rating and approval to produce HMA according to the current Bureau of Materials and Physical Research Policy Memorandum, "Approval of Hot-Mix Asphalt Plants and Equipment." The plants shall not be used to produce mixtures concurrently for more than one project or for private work unless permission is granted in writing by the Engineer. The plant units shall be so designed, coordinated and operated that they will function properly and produce HMA having uniform temperatures and compositions within the tolerances specified. The plant units shall meet the following requirements.

(a) Requirements for All Plants. All HMA plants shall be according to the following.

- (1) General. The plant shall be approved before production begins. All HMA plants shall be capable of producing HMA within the specification tolerances for gradation and asphalt binder content. The plant owner shall be responsible for demonstrating this capability through a production and testing program defined by the current Bureau of Materials and Physical Research Policy Memorandum, "Approval of Hot-Mix Asphalt Plants and Equipment". If the plant fails to maintain this capability, the Department may require the demonstration to be repeated at any time. Failure to maintain the capability may result in loss of plant approval status. Accessibility to the top of truck beds shall be provided by dual platforms or other suitable device to enable the Engineer to obtain samples and mixture temperature data.

For all types of plants, the ingredients shall be heated and combined in such a manner as to produce HMA which when discharged from the plant will in general vary not more than 20 °F (10 °C) from the temperature set by the Engineer. In all cases, the mix temperature shall not be more than 350 °F (180 °C) or less than 250 °F (120 °C). Wide variations in the mixture temperature of successive loads may be cause for rejection of the HMA.

During the drying process, the moisture content of the aggregate shall be reduced such that the moisture content of the HMA at time of discharge from the mixer will not exceed 0.3 percent. For certain

aggregates such as air-cooled blast furnace slag, and other highly absorptive aggregates, special handling and treatment such as double drying may be required.

Whenever a HMA plant is being used to produce High ESAL or Low ESAL mixtures as defined in Article 1030.01, all hot bins shall be emptied and all hot and cold aggregate in the dryer and on all collector conveyors shall be removed prior to starting production or resuming once production has been interrupted for the purpose of producing a different mixture.

- (2) **Storage Facilities.** The plant used in the preparation of the HMA shall be located where it will have adequate storage and transportation facilities. Sufficient space shall be provided for separate stockpiles of each gradation, source, and quality of aggregate required. If necessary to prevent the intermixing of the different materials, or if stockpiles join together, suitable partitions shall be used between adjacent stockpiles. All aggregates shall be kept separated until they are fed in their proper proportions onto a belt conveyor or into the boot of the cold aggregate elevator. The aggregates shall be handled in such a manner as to prevent contamination, degradation and segregation.
- (3) **Aggregate/RAP Feeders.** The plant shall be provided with accurate mechanical means for uniformly feeding each aggregate, and RAP if used, in the proper proportions so that uniform production and uniform temperature will be obtained. A minimum of four bins and feeders for aggregate will be required. If RAP is used, one additional bin and feeder will be required. If any of the aggregates used in preparing the mixture become intermixed in a bin compartment, the compartment shall be emptied and the intermixed material shall not be used. All aggregate feeders shall be calibrated to the desired volumes and/or weights for each aggregate/mixture, to the satisfaction of the Engineer. This calibration may require plant modification. The controls of the total quantity of combined aggregates fed to the dryer shall be by a variable speed system. Other methods may be approved by the Engineer. When the proportioning gates of the aggregate feeders are once set for proper blending, they shall be locked or bolted securely and their positions shall not be changed unless directed by the Engineer.
- (4) **Dryers.** The plant shall be equipped with a revolving cylindrical dryer or dryers capable of heating and drying all of the fine and coarse aggregates to a temperature of 250 to 350 °F (120 to 180 °C).
- (5) **Dust Collection.** The plant shall be equipped with a primary dust collector, approved by the Engineer, connected to a secondary dust collector (baghouse or wet-wash).

Material collected from the primary collector shall be discharged into a hopper which is equipped with the means of either wasting stored dust or metering and conveying its contents into the boot of the hot elevator. Metering of dust from the hopper shall be accomplished by either an adjustable variable speed vane or auger feeder. Feed shall be actuated

by a control located in the discharge chute between the dryer and the hot elevator, and shall only occur when aggregate is being discharged from the dryer. In all cases, the hopper used for storing the primary material shall be equipped with a low-bin indicator.

Material collected in the secondary collector (baghouse) shall not be stored internally, but shall be discharged directly into a silo. Feed of the material from the silo to the mix shall be accomplished only by weight (mass). In no case shall the collected secondary material be returned to the hot elevator. To meet job mix formula criteria, it may be necessary to waste some or all of the collected secondary material.

- (6) Hot-Mix Surge Bins. The Contractor may use a hot-mix surge system in the manufacture of HMA provided the bin(s) meet the following requirements and are operated to the satisfaction of the Engineer. The complete surge system shall be designed and operated to prevent segregation and loss of temperature of the mix. Maximum retention time shall be eight hours unless longer retention time is authorized in writing by the Engineer. When requested, longer retention time will be evaluated according to the current Bureau of Materials and Physical Research Policy Memorandum, "Storage of Hot-Mix Asphalt". The bin(s) shall be insulated and/or heated, and of an enclosed weatherproof type. A combination low level indicator and cutoff system shall be provided that will automatically stop the discharge of mix from the surge bin(s) when the mix falls below the top of the discharge cone. An alarm system, audible to personnel in the immediate plant area, shall be provided to sound automatically when the above system is bypassed. The conveying system used to transport the mix from the mixer to the bin(s) may be a continuous type or skip bucket type. The continuous type shall be enclosed, heated and/or insulated for effective control of mix temperature. The skip bucket must have sufficient capacity to transport an entire batch and mass dump into bin(s). Means must be provided to discharge the HMA into trucks, either from the mixer or by a diversion device, when required.

No surge system will be approved by itself but shall be considered as part of a complete operating HMA plant. The mix as discharged from the bin(s) shall meet all specification requirements for the mix being produced. Approval for the use of a surge system may be withdrawn at anytime, by the Engineer, for unsatisfactory operation.

IL-4.75 mixtures which contain aggregate having absorptions greater than or equal to 2.5 percent, or which contain steel slag sand, shall have a minimum silo storage plus haul time of 1.5 hours.

- (7) Temperature Recording Instrument. The plant shall be equipped with either a recording pyrometer or a recording thermometer having at least two terminals when a single dryer is used, and at least three terminals when a dual dryer is used. The type and accuracy of the recording instrument shall be approved by the Engineer. Unless otherwise approved, one terminal shall be installed at a suitable location at the discharge of each dryer and the others near the discharge gate in each

bin compartment used for fine aggregate. The temperature recording instrument shall be capable of making accurate charts of the temperatures during the day's run. The recording instrument shall be installed at a point free from the dust and vibration of the plant. If this instrument is not located as to indicate clearly to the plant operator the temperature of the mineral aggregates at the discharge of each dryer, a non-recording pyrometer shall also be installed in view of the plant operator. At the end of each day's run, the record sheet of the recording instrument shall be submitted to the Engineer.

- (8) Storage Tanks for Asphalt Binders. Tanks for the storage of asphalt binder shall be equipped to heat and hold the material at the required temperatures. The heating shall be accomplished by steam coils, hot oil coils, electricity or other approved means so that no flame shall be in contact with the tank. All asphalt lines and fittings shall be steam, electric or hot oil jacketed. Provisions shall be made for sampling the asphalt from the line leading to the weigh bucket or metering device. If more than one grade of asphalt binder is required for concurrent operations, adequate storage and separate piping to the weigh bucket or metering device for each grade, or other methods approved by the Engineer that prevent intermingling of the asphalt binders, shall be provided. An armored thermometer or pyrometer which will accurately show temperatures between 200 and 400 °F (95 and 205 °C) shall be suitably located in the asphalt line or within the tank. The instrument shall be located so as to indicate to the plant personnel, the temperature of the asphalt binder.
- (9) Equipment for Weighing HMA. The HMA shall be weighed on an approved scale furnished by the Contractor meeting the requirements of The Weights and Measures Act of the State of Illinois. Each time the scale is moved, the accuracy shall be retested and certified. For dryer drum plants the load-out scale used to weigh HMA shall be equipped with an automatic printer. Batch plants shall have an automatic printer to record the weight of all ingredient materials. The automatic printer shall be an integral part of the scale equipment or the scale and printer shall be directly connected in a manner that will prohibit the manual entry of weights, except as provided in paragraph a., below.
 - a. If the platform scale equipment measures gross weight (mass), the printer will record the gross weight (mass) as a minimum. Tare and net weights (masses) shall be shown on weigh tickets and may be printed automatically or entered manually.
 - b. If scale equipment on a platform scale zeros out the truck tare automatically, the printer shall record the net weight (mass) as a minimum.
 - c. If the scale equipment on a surge bin weigh hopper zeros automatically after discharging each batch, the printer shall record the net weight (mass) as a minimum.

- d. If the scale equipment on surge bins automatically shuts down the feed system weighing and weighs the amount in the silo before and after discharge, the printer shall record the net weight (mass) as a minimum.

The automatic printer shall produce a weight ticket in triplicate. Weights (Masses) shall be shown in tons (metric tons) to the nearest 0.01 ton (0.01 metric ton).

- (10) Equipment for Anti-Strip Additives. When an anti-stripping additive is required and a liquid additive is used, it shall be added to the asphalt binder by means of an approved in-line blending system located between the plant supply tank and distribution on the heated aggregate. The in-line blending system shall be installed in such a location that the liquid additive cannot recirculate and contaminate the supply tank. The in-line blending system shall be capable of delivering a consistent and controllable stream of material to the asphalt binder under all operating weather conditions and shall be capable of controlling the introduction of additive into the asphalt binder within ± 10 percent of the amount specified or required. The Contractor shall use methods and procedures for handling and storage of the additive which meet the manufacturer's safety recommendations.

When lime is used as the anti-stripping additive, a separate bin or tank and feeder system shall be provided to store and accurately proportion the lime onto the aggregate in either dry or slurry form. The lime and aggregate shall be mixed by a power driven pugmill prior to entering the dryer. In the event lime is added in dry form, the aggregate shall be dampened sufficiently to provide a uniform coating of lime. The feeder system shall be controlled by a proportioning device which shall provide accuracy to within ± 10 percent of the specified amount of lime solids. The proportioning device shall have a convenient and accurate means of calibration and shall be interlocked with the aggregate feed or weight system so as to maintain the required proportion. A flow indicator or sensor shall be provided and interlocked with the plant controls such that the production of the mixture will be interrupted if there is a stoppage of the lime feed. The stockpiling of lime treated aggregate will not be permitted. The methods of introducing and mixing the anti-stripping additive and aggregate shall be subject to approval by the Engineer prior to beginning production.

- (11) Equipment for RAP. When the RAP option is used, the plant shall be modified to ensure a homogenous, uniformly coated mix is obtained. A scalping screen, crushing unit or comparable sizing device shall be used in the RAP feed system to remove or reduce oversized material. Modifications shall be approved by the Engineer.

- (12) For mixture IL-4.75, mineral filler and collected dust (baghouse) shall be proportioned according to the following.

- a. Mineral filler shall not be stored in the same silo as collected dust (baghouse).

- b. Additional minus 200 material needed to meet the Job Mix Formula (JMF) shall be manufactured mineral filler, unless otherwise approved by the Engineer.
- c. Collected dust (baghouse) may be used in lieu of manufactured mineral filler according to the following.
 - 1. Sufficient collected dust (baghouse) is available for production of the IL-4.75 mixture for the entire project.
 - 2. A mix design was prepared based on collected dust (baghouse).
- d. A combination of collected dust (baghouse) and manufactured mineral filler may be used according to the following.
 - 1. The amount (proportion) of each shall be established and not varied.
 - 2. A mix design was prepared based on the established proportions.

(b) Batching Plants. Batch plants shall be according to the following.

- (1) Equipment for Weighing or Measuring Aggregate/RAP. The equipment shall include a means for accurately weighing each size of aggregate in a weigh box or hopper suspended on scales and of ample size to hold a full batch without hand raking or running over. The gate shall close tightly so that no material is allowed to leak into the mixer while a batch is being weighed.

If the aggregates are measured by volume in calibrated compartments, the calibrated compartments shall form the weigh hopper and shall be arranged so that the volume measurement of each compartment and each batch may be checked by weight (mass). The means of checking the volume measurement shall meet the approval of the Engineer. RAP material shall be weighed prior to entering the pugmill.

The scale shall be a springless dial scale complying with the requirements of Article 1103.02(c). Load cells with digital readouts may be used if approved by the Engineer. The scale shall have a capacity of not more than twice the weight (mass) of the approved capacity of the mixer.

- (2) Mineral Filler Elevating System. The mineral filler shall be weighed in the aggregate weigh hopper or measured by volume in a calibrated compartment. It shall be conveyed to the weigh hopper by approved means. The mineral filler feeding system shall be so arranged that the accuracy of feed will not be affected by the head of material in the mineral filler bin. The feeding method shall operate in such manner as will enable small fractions of the material to be weighed. The chute

used to introduce the mineral filler into the weigh hopper shall be so constructed that none of the material is retained in it after the required amount has been deposited in the weigh hopper.

- (3) Equipment for Weighing or Measuring Asphalt Binder. The equipment used for weighing or measuring the asphalt binder shall consist either of an approved weigh bucket or metering device. If a weigh bucket is used, it shall be a non-tilting type and shall be completely suspended from a springless dial scale. Load cells with digital readouts may be used if approved by the Engineer. The weigh bucket, its discharge valve or valves and spray bar shall be adequately heated and shall have a capacity of at least 15 percent in excess of the weight (mass) of asphalt binder required in any batch. Adequately heated, quick-acting, non-drip valves shall be used in charging the bucket.

If a metering device is used, it shall be of an approved design and have a capacity of at least 15 percent in excess of the quantity of asphalt binder used in a batch. The controls shall be constructed so that they may be locked at any dial setting and will automatically reset to that reading after the addition of asphalt binder to the mix. The dial shall be in full view of the mixer operator. The flow of asphalt binder shall be automatically controlled so that it will begin when the dry mixing period is over. The section of the asphalt line between the charging valve and the spray bar shall be provided with a valve and outlet for checking the meter.

Either the weigh bucket or the meter device shall discharge all the asphalt binder required for one batch in not more than 15 seconds after the flow has started. The size and spacing of the spray bar openings shall provide a uniform application of asphalt binder the full length of the mixer.

- (4) Accuracy of Scales. The scales shall meet the requirements of The Weights and Measures Act of the State of Illinois. The scales shall be calibrated at the beginning of each construction season and as often as the Engineer may deem necessary to assure their continued accuracy. Ten standard 50 lb (25 kg) weights meeting the requirements of NIST shall be available at the HMA plant for use in calibrating and testing the weighing equipment. The scales shall be inspected frequently for sensitivity, sluggishness or damage. They shall be checked for accuracy at intervals of not more than one week by obtaining the net weight (mass), on truck scales, of a truck load of HMA.
- (5) Pugmill Mixer. The batch mixer shall have a rating plate attached showing the manufacturer's rated capacity, and shall be an approved type capable of producing a uniform mixture within the job tolerances. If not enclosed, the mixer box shall be equipped with a dust hood to prevent loss of dust. The clearance of the blades from all fixed and moving parts shall not exceed 3/4 in. (20 mm).

The capacity of the pugmill mixer will be determined by the Engineer based on 115 percent of the calculated net volume of the mixer below

the center of the mixer shafts and 100 lb/cu ft (1600 kg/cu m) material. If the mixer will not operate efficiently at the approved capacity, or if its production does not coordinate with other plant units, the right is reserved to reduce the size of the batch until the desired efficiency is obtained. The Engineer's decision as to the permissible capacity of the pugmill mixer will be final.

The mixer shall be heated by an approved method and shall have a capacity of not less than 2000 lb (905 kg) for any composition required under these specifications. The amount of material which the Contractor will be permitted to mix per batch shall be determined by the Engineer. The mixer shall be of the twin-shaft type.

- (6) Time Lock. The mixer shall be equipped with an accurate time lock to control the operations of a complete mixing cycle. It shall lock the weigh hopper gate after the charging of the mixer until the closing of the mixer gate at the completion of the cycle. It shall lock the asphalt binder bucket throughout the dry mixing period and shall lock the mixer gate throughout the dry and wet mixing periods. The dry mixing period is defined as the interval of time between the opening of the weigh hopper gate and the start of introduction of asphalt binder. The wet mixing period is the interval of time between the start of introduction of asphalt binder and the opening of the mixer gate.

The heated aggregates, RAP when used, and mineral filler shall be mixed in the pugmill mixer for a period of not less than 10 seconds. The asphalt binder shall then be added and the mixing continued. The time required to add the asphalt binder shall be not more than 15 seconds. The total time required for adding the asphalt binder and completing the wet mixing period shall be not less than 35 seconds, or longer if necessary, to produce a homogeneous mixture in which all particles of aggregate are coated uniformly. If a question as to the degree of coating should arise, AASHTO T 195 shall be used. When the RAP option is used, the mix time may vary in relation to the nature of the aggregate. The total mixing time shall be a minimum of 45 seconds consisting of dry and wet mixing. The times of dry and wet mixing shall be set by the Engineer. The same size batch weights shall be used in the production of HMA, unless permission to change is granted in writing by the Engineer.

The control of the timing shall be flexible and capable of being set at intervals of five seconds or less throughout a total cycle. The setting of time intervals shall be at the direction of the Engineer.

- (7) Batch Counter. An approved mechanical batch and/or tonnage counter shall be installed as part of the time lock device. It shall register only upon the actuation of the asphalt weigh bucket or valve release. It shall not register any dry batches or any material released during the operation of pulling the bins.
- (8) Screens. The screens used in separating the aggregates shall be of the vibrating types, and when operated at normal speeds shall separate the

aggregates satisfactorily. The screening system shall be equipped with a scalping screen having openings not more than 1/2 in. (13 mm) larger than the largest size aggregate used in preparing the HMA. The screening system shall have a tailing pipe for the removal of oversized aggregate. The discharge point of the tailing pipe shall be located so that it will not create a hazard or nuisance. The screens shall produce aggregate in the proper bins, as required.

Efficiency of separation based on laboratory sieves, shall be such that no more than 20 percent of the material in the bin is smaller than the nominal size nor more than ten percent over size for that bin.

- (9) Hot Aggregate Bin. The plant shall be equipped with a minimum of four aggregate storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be arranged to assure separate and adequate storage of appropriate fractions of the mineral aggregates. Separate dry storage shall be provided for mineral filler, and the plant shall be equipped to feed the material into the aggregate weigh hopper. Each bin shall be provided with overflow pipes, of such size and at such locations as to prevent backing up of material into other compartments or bins. Material from the overflow pipe shall not be returned to the hot elevator. Each compartment shall be provided with its individual outlet gate, constructed so that when the gate is closed, there shall be no leakage. Gates shall cut off quickly and completely. Bins shall be so constructed that samples can be readily obtained. A sampling device having the same width as the hot aggregate bin outlet gates shall be provided for this purpose. Hot aggregate bins shall not be modified in any manner nor shall divider plates be removed.
- (c) Continuous Mixing Plants. Continuous mixing plants shall be according to the following.
 - (1) Gradation Control Unit. The plant shall include means for accurately proportioning each size of aggregate, RAP if used, and mineral filler.

The plant shall have a feeder mounted under each compartment bin. Each compartment bin shall have an accurately controlled individual gate to form an orifice for volumetrically measuring the material drawn from each compartment. The feeding orifice shall be rectangular with one dimension adjustable by positive mechanical means provided with a lock.

Bins shall be equipped with adequate telltale devices to indicate the position of the aggregates in the bins at the lower quarter points.

A cutoff system shall be provided which shall automatically stop the mixing operations when any bin becomes empty or when the asphalt binder reaches a level in the tank where the specified quantity of asphalt binder is not delivered to the pugmill.

Indicators graduated in 0.10 in. (2.5 mm) divisions and marked in inches (millimeters) shall be provided on each gate to show the gate opening.

- (2) **Weight Calibration of Aggregate/RAP Feed.** The plant shall include a means for calibration of gate openings by weighing test samples. Provision shall be made so that materials fed out of individual orifices may be bypassed to individual test boxes. The plant shall be equipped to conveniently handle individual test samples weighing not less than 200 lb (90 kg). Accurate scales shall be provided by the Contractor to weigh such test samples.
- (3) **Synchronization of Aggregate/RAP Feed and Asphalt Binder Feed.** Satisfactory means shall be provided to afford positive interlocking control between the flow of aggregate/RAP from the bins and the flow of asphalt binder from the meter or other proportioning device.

This control shall be accomplished by interlocking mechanical means or by any other positive method satisfactory to the Engineer.

A revolution counter graduated in 0.01 revolution shall be conveniently located on the plant. A convenient means shall be provided for checking, by weight (mass), the flow of the asphalt binder.

- (4) **Mixer.** The plant shall include a continuous mixer of an approved twin shaft type that is adequately heated and capable of producing a uniform mixture within the job mix formula tolerances. It shall be equipped with a discharge hopper having a minimum capacity of 1 ton (1 metric ton), and dump gates which will permit rapid and complete discharge of the mixture. The paddles shall be adjustable for angular position on the shafts and reversible to retard the flow of the mix. The spray bar of the mixer shall be equipped with a pressure gauge. An adjustable baffle or dam which can be locked or bolted in position shall be placed at the discharge end of the pugmill. The mixer shall have a nominal capacity, as determined by the Engineer, of not less than 60 tons (55 metric tons) per hour and shall have a manufacturer's plate giving the net volumetric contents of the mixer at the several heights inscribed on a permanent gauge. Charts shall be provided showing the rate of feed of aggregate per minute for the aggregate being used. Unless otherwise required, the mixing time shall be determined by the weight method using the following formula. The weights (mass) will be determined for the job by tests made by the Engineer.

$$\begin{array}{lcl} \text{Mixing time} & & \text{Pugmill dead capacity, lb (kg)} \\ \text{in seconds} & = & \text{Pugmill output, lb (kg) /sec.} \end{array}$$

For High ESAL and Low ESAL mixtures, as defined in Article 1030.01, the heated aggregates, mineral filler, RAP when used, and asphalt binder shall be mixed in the pug mill mixer for a period of not less than 45 seconds, or longer if necessary, to produce a homogenous mixture in which all particles of aggregate, and RAP when used, are coated uniformly. If a question as to the degree of coating should arise, AASHTO T 195 shall be used.

(d) **Dryer Drum Plants.** Dryer drum plants shall be according to the following.

- (1) **General.** General requirements shall be according to Article 1102.01(a), except (3), (4), (5), and (7) will not apply, and a hot-mix surge bin meeting the requirements of (6) shall be utilized.

The heated aggregates, mineral filler, asphalt binder, and RAP when used, shall be proportioned by electronic proportioning equipment and mixed to produce a homogenous mixture in which all particles of aggregate are coated uniformly. If a question as to the degree of coating should arise, AASHTO T 195 shall be used. If the Engineer ascertains that proper mixing is not being obtained, adjustments shall be made in the plant operation (production rate, dryer drum slope, etc.) to assure that these conditions are met.

- (2) **Aggregate/RAP Bins and Feeders.** The bins shall be designed to prevent overflow of material from one bin to another. Each bin shall be provided with a variable speed belt or apron feeder with adjustable gates which can be locked. Each bin shall have a cutoff system that shall automatically stop the feeding operation when any bin becomes empty. The combined aggregates shall pass over a vibrating scalper that will remove all material and aggregate greater than the nominal top size gradation permitted by the specification for the mixture being produced, or as set by the Engineer, prior to the aggregates being placed on the weigh belt. The scalper shall be independent of other proportioning or weighing equipment.
- (3) **Aggregate/RAP Weighing Equipment.** The combined aggregates, and RAP if used, shall be weighed on continuous belt weighing devices meeting the requirements of the NIST Handbook #44. The weigh belts shall be self-aligning with a gravity belt takeup and rigid wind guards at the weighing section. Sun screens may be required by the Engineer at the weighing section. Means shall be provided to divert the aggregate/RAP into a truck, after passing over the weigh belt scales. In order to obtain samples, the Contractor may choose to either stop the weigh belts when requested by the Engineer, or provide an automatic sampling device meeting the approval of the Engineer.
- (4) **Mineral Filler System.** Mineral filler shall be proportioned to the mixing zone of the HMA plant by a variable speed vane feeder and storage system or other systems approved by the Engineer. Means must be provided to divert material from the proportioning unit for purposes of calibration. The feeder shall be provided with an automatic cutoff system in the event the feeder is blocked or is devoid of material.
- (5) **Asphalt Binder System.** The asphalt binder system shall consist of a temperature compensating meter and pump. Other asphalt binder systems may be used if approved by the Engineer. The pump and meter shall be installed as close to the asphalt binder storage tank(s) as possible using rigid pipe with a minimum of piping length and bends. The diameter of the pipe shall be consistent throughout the system.

Means shall be provided to automatically stop the plant in the event asphalt binder ceases to flow through the meter.

- (6) **Dryer Drum Mixer.** Dryer drum mixer components shall have a minimum capacity of 60 tons (55 metric tons) per hour of HMA. The units shall have a recording pyrometer or thermometer that records the discharge temperature of the mixture.
 - a. **Single Unit Dryer Drum Mixers.** The single unit dryer drum mixer shall be a revolving cylindrical drum capable of heating, drying, and mixing the combined aggregates, RAP if used, mineral filler when required, and asphalt binder to produce a uniformly coated, homogenous HMA meeting all applicable specifications. The dryer burner shall be equipped with automatic controls.
 - b. **Dual Unit Dryer Drum Mixers.** The dryer portion of the dual unit dryer drum mixer shall be a revolving cylindrical drum capable of heating and drying the combined aggregates to the required specifications. The mixer portion of the dual unit dryer drum mixer shall be either a revolving cylindrical drum or a continuous twin shaft pugmill with a compatible mixing capacity to the dryer production rating. The unit shall be capable of mixing the heated and dried combined aggregates, RAP if used, mineral filler when required, and asphalt binder to produce a uniformly coated, homogenous HMA meeting all applicable specifications.
- (7) **Dust Collector.** If a baghouse is utilized, the collected dust shall be returned to the dryer at a uniform rate at a point where the asphalt binder is added to the mixing zone of the HMA plant. Other dust collection systems will be permitted if approved by the Engineer.

If positive dust control equipment (PDCE) is required, it shall consist of a system that is an integral part of the production process. The system shall accurately weigh all of the secondary dust collected in the baghouse, transfer the material to a storage silo, accurately weigh the required amount of fines to be returned from the storage silo, and transfer them back to the mixture. The PDCE weighing devices shall have an accuracy of 0.5 percent of the actual weight of the material. The system shall be capable of automatically monitoring the dust collection process and adjusting the amount of asphalt binder added to the mixture. The entire system shall be interlocked with the plant controls to respond to production rate changes, start up, and shut down situations. The weighing process shall be displayed and recorded in 0.1 units. The PDCE shall be capable of accurately wasting dust without having any adverse effects on the mixture.

- (8) **Proportioning Control Systems.**
 - a. **Aggregate/RAP Feed Control.** Each aggregate feeder shall have an adjustable feed control, which can be locked, with a master control that will automatically increase or decrease the production rate of each feeder proportionately when the total rate of production

is changed. The revolutions per minute (RPM), tons/hour (TPH), etc. of all feeders shall be measured at the tail shaft of the feeder. The feeders shall have an accuracy of ± 1.0 percent of the actual quantity of material delivered.

- b. Aggregate/RAP Weighing. The main proportioning weigh belt shall be electronically interfaced with the asphalt binder, RAP if used, and mineral filler system to proportion the required amount of each material simultaneously to the mixer. The aggregate, and RAP if used, weighing systems shall have an accuracy of ± 0.5 percent of the actual material weighed by the belts. The weighing system shall also have a high-low adjustable tolerance indicator that will signal the operator audibly when the actual production rate differs from the preset rate by more than 3.0 percent.
 - c. Mineral Filler Control. Mineral filler shall be added to the mixer by a variable speed proportioning system interfaced with the aggregate weigh belt that will indicate total dry aggregate combined (aggregates + mineral filler) weight (mass) to the asphalt proportioning system. The mineral filler system shall have an accuracy of ± 0.5 percent if the mineral filler is measured by weight (mass), or ± 8.0 percent if the mineral filler is measured solely by volume, of the actual material measured by the system. The mineral filler shall be added in the mixer at the same point the asphalt binder is added in order that no filler is lost as fugitive dust. Other systems will be permitted if approved by the Engineer.
 - d. Asphalt Binder Control. The required quantity of asphalt binder shall be proportioned to the mixer via a temperature compensating meter that will correct the quantity of asphalt binder to 60 °F (15 °C), or a system approved by the Engineer. This system shall be electronically interfaced with the combined dry aggregates, RAP if used, and mineral filler. The meter shall have an accuracy of ± 0.4 percent of the actual material metered.
 - e. Aggregate/RAP Moisture Compensators. The moisture compensation devices shall be capable of electronically converting the wet aggregate/RAP weight (mass) to dry aggregate/RAP weight (mass). Other systems will be permitted if approved by the Engineer.
- (9) Control Console. The following items shall be part of the operator's control console.
- a. Aggregate/RAP Feed Controls. The variable speed controls, both total and proportional for each feeder and combined aggregates or RAP if used, shall be indexed in units with a minimum unit of 0.1. The rate in RPM or TPH, etc. shall be displayed by a digital readout for each feeder with a minimum unit of 0.1 RPM or 1 TPH, etc.
 - b. Aggregate/RAP Weight (Mass) Indicator. The accumulated wet weight (mass) of material in tons (metric tons) that passes over

each weigh belt shall be available at the control console with a minimum unit of 0.1 ton (0.1 metric ton). The dry weight (mass) of material, in TPH, passing over each weigh belt shall be displayed by digital readouts with a minimum unit of 1 TPH.

- c. Mineral Filler Control. Mineral filler shall be controlled by a variable speed control with a minimum unit of 0.1 and shall be displayed in RPM, or TPH, etc. with a minimum unit of 0.1 RPM or 0.1 TPH, etc.
 - d. Asphalt Binder Control. The asphalt binder control shall be capable of presetting the actual asphalt binder content directly as a percent of the total weight (mass) of mixture with a minimum unit of 0.1 percent. The asphalt binder rate shall be displayed to a minimum unit of 0.1. A control shall be provided to set the specific gravity or weight/gallon (mass/liter) of the asphalt binder. The temperature of the asphalt binder shall be recorded by a recording pyrometer or thermometer at the console.
 - e. Aggregate/RAP Moisture Compensators. The compensators shall be part of the operator's console and shall have a minimum unit of 0.1 percent. The control shall be lockable if the moisture setting is not printed as part of the record.
 - f. HMA Temperature. The temperature of the mixture shall be recorded in °F (°C) by a recording pyrometer or thermometer at the console.
- (10) Recording of Proportions. The plant shall be equipped with a digital printer that will automatically print the following data at six minute intervals during production time and on demand. All readings shall show the date, month and year, and time to the nearest minute for each print.
- a. Accumulated dry aggregate/RAP in tons (metric tons) to the nearest 0.1 ton (0.1 metric ton).
 - b. Accumulated mineral filler in revolutions, tons (metric tons), etc., to the nearest 0.1 unit.
 - c. Accumulated asphalt binder in gallons (liters), tons (metric tons), etc., to the nearest 0.1 unit.
 - d. Aggregate/RAP Moisture Compensators in percent as set at the panel. (Required when accumulated dry aggregate/RAP is printed in Wet Aggregate/RAP Weight (Mass)).

Another system approved by the Engineer, such as a fully computerized system, that will provide the control and documentation of the above equipment, will be permitted.

- (e) Plants Producing All Other Mixtures (as defined in Article 1030.01). Plants producing All Other Mixtures shall be according to the following.

- (1) Batching Plants. The following special requirements shall apply to batching plants.
 - a. Article 1102.01(a)(3) shall not apply, unless aggregates are blended to achieve the required gradation.
 - b. Article 1102.01(b)(2) shall not apply, unless mineral filler is used to achieve the required gradation.
 - c. Articles 1102.01(b)(6), (7), (8), and (9) shall not apply.
- (2) Continuous Plants. Article 1102.01(c)(1) shall not apply.
- (3) Dryer Drum Plant. The following special requirements shall apply to dryer drum plants.
 - a. General. The general requirements shall be according to Article 1102.01(d), except as follows.

The plant shall be calibrated and approved prior to the start of production. Adequate means shall be provided to divert the individual or combined aggregates, and RAP if used, into a truck after the aggregates or RAP pass over the weigh belt(s) and prior to being deposited into the dryer or drum mixer. The asphalt metering system shall be calibrated at the same time as the weigh belt(s) by diverting the asphalt binder into a tank.
 - b. Article 1102.01(d)(3), (8) and (9) shall not apply.
 - c. Aggregate/RAP Feeders. The plant shall be provided with an accurate mechanical means for uniformly feeding each aggregate, and RAP if used, in its proper proportion into the dryer or drum mixer so that uniform production and temperatures will be obtained. One bin and feeder will be required for each aggregate and RAP material proportioned into the mix. Each bin shall have a low level warning device that will sound when the aggregate or RAP in any bin is less than 12 in. (300 mm) above the top of the discharge gate. A scalper or other device that will remove large clay lumps or debris will be required prior to the aggregates being placed on weigh belts. The RAP material shall be processed according to Article 1102.01(a)(12).
 - d. Mineral Filler System. A mineral filler system meeting the approval of the Engineer will be required when the final mix does not contain the required amount of minus No. 200 (75 µm) sieve material.
 - e. Proportioning Control. The combined aggregates shall pass over a weigh belt or belt scale that is electronically interlocked with the asphalt pump and will proportion the proper amount of asphalt binder at the point where the aggregate and asphalt binder are simultaneously being added to the dryer or drum mixer. RAP, if

used, shall be interlocked with the aggregate weigh belt to proportion the proper amount of material to the mixing unit. The weigh belt shall have an electronic readout or display at the operator's station that shows the total ton (metric ton) per hour passing over the belt. The asphalt binder pump shall be a positive displacement type pump with a circulating asphalt system that calibrates within 0.5 percent of the theoretical asphalt at any given production rating. The asphalt binder pump shall be equipped with a revolution counter or meter and a pyrometer or thermometer probe to record the asphalt binder temperature with the data being transmitted to the operator's station.

- f. Control Devices. The following items shall be part of the operator's control console.
 1. Cold aggregate/RAP feed controls which indicate the relative output of each individual feeder and which have the capability of both individual and proportional control of the aggregates and RAP.
 2. Dryer burner controls which automatically control the temperature of the mix and record the mix temperature at the dryer discharge.
 3. Weigh belt readouts which indicate the amount of material crossing the belts.
 4. Asphalt pump revolution counter or meter readout which indicates the asphalt binder being proportioned into the mix and a recording pyrometer or thermometer which records the asphalt binder temperature prior to entering the pump.
 5. Proportioning control dials for setting the asphalt content and making the moisture adjustments that are capable of being key locked.

1102.02 Reserved.

1102.03 Spreading and Finishing Machine. Hot-mix asphalt (HMA) pavers shall be self-contained, power-propelled units equipped with augers, activated screed or a strike off assembly and be capable of being heated. The augers, activated screed or strike off assembly shall be adjustable either automatically or by adding additional sections so the paver will place, compact or strike off the HMA to the full width being placed. All width extensions shall have the same placement features and equipment functions as provided on the main body of the paver. Pavers with extendible type screeds shall have a minimum 10 ft (3 m) basic screed, except on projects with 7500 sq yd (6300 sq m) or less of HMA. For these smaller projects, a minimum 8 ft (2.4 m) basic screed will be permitted. Augers shall be extended as additional sections of screed are bolted on or automatically adjustable screeds are extended. The augers need not be extended when the screed extensions on each side of the machine are 1 ft (300 mm) or less if the finished surface of the mat is uniform. Pavers used for shoulders and similar construction shall be capable of

spreading and finishing HMA in widths shown on the plans. The use of any machine obsolete in design or in poor mechanical condition will not be permitted.

The spreading and finishing machine shall be equipped with an automatic electronic grade control device. The device shall be effective in leveling depressions in the surface of the existing pavement, the leveling course and the binder course.

The automatic electronic grade control device shall be capable of controlling the elevation of the screed relative to either a preset grade control stringline or a grade reference device traveling on the adjacent pavement surface. The traveling grade reference device shall be not less than 30 ft (9 m) in length.

The paver shall be equipped with a receiving hopper having sufficient capacity for a uniform spreading operation. The hopper shall be equipped with a distribution system to uniformly place a non-segregated mixture in front of the screed. The distribution system shall have chain curtains, deflector plates, and/or other devices designed and built by the paver manufacturer to prevent segregation during distribution of the mixture from the hopper to the paver screed. The Contractor shall submit a written certification that the devices recommended by the paver manufacturer to prevent segregation have been installed and are operational. Prior to paving, the Contractor, in the presence of the Engineer, shall visually inspect paver parts specifically identified by the manufacturer's check list for excessive wear and the need for replacement. The Contractor shall supply the completed check list to the Engineer noting the condition of the parts. Worn parts shall be replaced. The Engineer may require an additional inspection prior to placement of the surface course or at other times throughout the work.

The screed or strike off assembly shall effectively produce a finished surface of the required evenness and texture without tearing, shoving or gouging the mixture.

The paver shall be capable of being operated at forward speeds consistent with satisfactory placement of the mixture.

A straightedge at least 4 ft (1 m) in length and equipped with a carpenter's level shall be available at the spreading and finishing machine to check the surface of the HMA for transverse slope and longitudinal surface variations.

1102.04 Aggregate Spreaders. The aggregate spreader used in placing aggregates in layers of 1 to 12 in. (25 to 300 mm) shall be of a design approved by the Engineer. The aggregate spreader shall contain a strike off plate capable of being adjusted so as to place the material in uniform layers from 1 to 12 in. (25 to 300 mm) in depth. It shall be equipped with two end gates or cut off plates, so that the aggregates may be spread in widths varying up to lane width.

The aggregate spreader used in spreading aggregate for surface treatments, keystone coat and seal coats shall be of a mechanical type approved by the Engineer. It shall distribute the aggregate uniformly, and shall be capable of being adjusted so that the spreading rate of the aggregate will not vary more than 2 lb/sq yd (1 kg/sq m).

The aggregate spreader used for reflective crack control treatments shall be a self-propelled machine with an aggregate receiving hopper in the rear, belt conveyors

to carry the aggregate to the front, and a spreading hopper equipped with full-width distribution auger and spread rolls. The spreader shall be in good mechanical condition and be capable of applying the cover material uniformly across the spread at the specified rate.

1102.05 Pressure Distributor. The pressure distributor used for applying liquid bituminous materials shall be a self-propelled motor vehicle and shall meet the following requirements.

- (a) Truck. The truck shall be capable of operating smoothly at speeds as low as 0.8 mph (1.3 km/h) when used on heavy penetration construction, and at normal road speeds when used for transporting bituminous materials. In order to develop these speeds satisfactorily, the truck shall have at least four speeds forward.
- (b) Tank. The tank on the distributor shall have a capacity of not less than 600 gal (2250 L). Approval shall be obtained from the Engineer for the use of a distributor having a capacity greater than 2500 gal (9450 L). The tank shall be covered with at least 1 in. (25 mm) of approved insulation. It shall be equipped with a removable manhole cover, an overflow pipe and a suitable strainer located at the intake or outlet to the pump to prevent the passage of any material which might clog the nozzles. A dial gauge plainly visible to the spray bar operator shall be conveniently placed to indicate the contents of the tank at various levels.
- (c) Heating System. The distributor shall be equipped with an approved heating system to heat the bituminous material. The heating system shall consist of heat flues having sufficient radiation to ensure the rapid circulation of hot gases of combustion from one or more efficient smokeless burners of the torch type, a circulating device to ensure uniform heating of the material, and a suitable fuel supply tank.
- (d) Pump. The distributor pump shall be of the rotary positive pressure type of sufficient size and discharge capacity to apply uniformly the specified amount of bituminous material in widths up to 24 ft (7.2 m). It shall be driven in the most direct method obtainable by a gasoline motor other than the vehicle propelling motor or by other methods approved by the Engineer. The pump motor shall have sufficient power to operate the distributor pump at the required volume and pressure. If the motor pump is equipped with a transmission, it shall have a governor. Suitable housing or heating jackets shall be provided to enclose the distributor pump and piping in order to retain the heat and to ensure a constant, even flow of the material.
- (e) Spray Bars. Spray bars of various lengths shall be used to spray the bituminous material over widths varying from 4 to 24 ft (1.2 to 7.2 m). The spray bars shall be arranged so that they may be swung from side to side over a distance of not less than 9 in. (225 mm) to match joints and to clear obstructions. They shall be equipped with spray nozzles of such design and size of orifice as to ensure uniform distribution of the bituminous material in the specified quantities.

Means shall be provided to stop the flow of bituminous material quickly and to prevent it from dripping when the flow is shut off. Means shall be provided for obtaining samples of the material from the tank or from the piping leading from the tank to the spray bars.

A hand spray bar and nozzle having a suitable length of flexible hose with packed couplings shall be provided for applying material at intersections, shoulders and similar locations.

- (f) **Thermometer.** A mercury thermometer having the stem extending into the material or into an approved well shall be placed in a suitable position in the tank to give a true average temperature of the contents of the tank.
- (g) **Operator's Platform.** A substantial platform for the operator shall be provided at the rear of the distributor. It shall be so located that it will provide a clear view of the operation of the spray bars.
- (h) **Tachometer or Synchronizer.** A tachometer shall be attached to the truck in such a manner as to be visible to the truck operator and to enable him/her to maintain the constant speed necessary for the correct application of the specified quantity of bitumen. Suitable charts shall be furnished showing the truck speeds necessary to obtain the required results. When a synchronizer is used, the tachometer may be omitted. The synchronizer shall deliver a specified quantity of bituminous material on the road surface regardless of the speed of the truck.
- (i) **Calibration.** The distributor will be calibrated by the Engineer before the work is started and the Contractor shall furnish all equipment, tools, materials and assistance necessary to make the calibration.

1102.06 Reserved.

1102.07 Heating Equipment. The heating equipment shall have sufficient capacity to heat the bituminous material properly by circulating steam or hot oil through coils of the tank car or storage tank, or by any other method approved in writing by the Engineer. Tank cars which have defective coils or which are without coils will be rejected on the work by the Engineer unless some satisfactory auxiliary means can be provided by the Contractor to heat the bituminous material without the introduction of moisture. The use of any equipment to agitate the bituminous material while it is being heated will be prohibited if, in the opinion of the Engineer, it injures, or in any way changes the characteristics of the bituminous material. The use of a tank car connection or any other equipment by means of which free steam or hot oil can be introduced directly into the bituminous material will not be permitted.

1102.08 Reserved.

1102.09 Reserved.

1102.10 Reserved.

1102.11 Micro-Surfacing Mixing Machine. The mixing machine shall be a self-propelled continuous flow mixing unit equipped with a chain dragged conveyor

belt aggregate delivery system and an interconnected positive displacement gear pump to accurately proportion and deliver ingredients to a revolving multi-blade mixer and discharge the thoroughly-mixed product on a continuous flow basis. The twin-shafted multi-blade pugmill shall be a minimum of 50 in. (1270 mm) long. The emulsion shall be introduced above the third point of the mixer to ensure proper pre-mixing of the aggregate, cement, additive, and water when the modified emulsified asphalt is added. Blade size and side clearances shall meet the equipment manufacturer's recommendations. The machine shall have sufficient storage capacity for aggregate, emulsified asphalt, mineral filler and water to maintain an adequate supply to the proportioning control. The machine shall be equipped with self-loading devices which provide for the loading of all materials while continuing to lay micro-surfacing, thereby eliminating unnecessary construction joints. The mixer shall be equipped with a remote forward speed control at the back mixing platform so the back operator can control forward speed and level of mixture in the paver box or rutbox.

Individual volume or weight controls for proportioning each material to be added to the mix shall be provided. Each material control device shall be calibrated and properly marked. They shall be accessible for ready calibration and so placed that the Engineer may determine the amount of each material used at any time.

The aggregate feed to the mixer shall be equipped with a revolution counter or similar device so that the amount of aggregate used may be determined at any time.

The emulsion pump shall be the positive displacement type and shall be equipped with a revolution counter or similar device so that the amount of emulsion used may be determined at any time.

The mixing machine shall be equipped with a water pressure system and nozzle type spray bar to provide a water spray immediately ahead of and outside the spreader box. The mixing machine shall be equipped with a fines feeder that provides an accurate metering device or method to introduce a predetermined proportion of mineral filler into the mixer at the same time and location that the aggregate is fed. The fines feeder shall be used whenever mineral filler is a part of the aggregate blend.

1102.12 Micro-Surfacing Spreader. The micro-surfacing spreader shall be a mechanical type squeegee box equipped with paddles mounted on adjustable shaft to continually agitate and distribute the mix throughout the box. The spreader shall be attached to the mixing machine and shall provide sufficient turbulence to prevent the mix from setting in the box or causing excessive side build-up or lumps. The squeegee box shall be equipped with flexible seals attached to the front and rear, and in contact with the pavement surface, to prevent loss of mixture from the box. A specially designed rutbox with a steel strike off capable of placing a crown in the mix shall be provided for filling ruts. The equipment shall be capable of filling cracks and minor surface irregularities and achieving a uniform surface without causing skips, lumps, or tears in the finished surface.

SECTION 1103. PORTLAND CEMENT CONCRETE EQUIPMENT**1103.01 Concrete Mixers.** Concrete mixers shall be as follows.

- (a) **Stationary Mixer.** The mixer shall be the batch type. The mixer used for paving shall have a rated capacity of not less than 28 cu ft (0.8 cu m) of mixed concrete. The mixer shall be capable of discharging the concrete directly into truck agitators, truck mixers operating at agitating speed, or non-agitating trucks for transport to the jobsite. The mixer for structures and incidental construction shall have a rated capacity of not less than 10 cu ft (0.25 cu m) for structures involving the placement of 30 cu yd (23 cu m) or more, and not less than 7 cu ft (0.2 cu m) of mixed concrete for placements less than 30 cu yd (23 cu m).

The mixer shall be equipped with a batch meter for counting the batches, and an approved timing device which will automatically lock the discharge lever during the full time of mixing and release it at the end of the mixing period. The timing device shall be equipped with a bell, adjusted to ring each time the lock is released. If the timing device becomes broken or out of order, the Contractor will be permitted to operate while it is being repaired, provided the Contractor furnishes an approved timepiece equipped with minutes and seconds, and provided that each batch is mixed 1 1/2 minutes. If the timing device is not repaired within 72 hours, further use of the mixer will be prohibited until repairs are made.

When measuring water by volume, the mixer shall be equipped with a water measuring device which shall be capable of measuring and discharging the specified amount of water within a limit of accuracy of one percent, except a limit of accuracy closer than 1 qt (1 L) will not be required, and shall be so arranged that the accuracy of measurement will not be affected by variations in pressure in the water supply line. A water glass placed vertically on the water tank shall not be used as a water measuring device. The water measuring equipment shall include an auxiliary tank of approved design from which the water measuring tank shall be filled. The volume of the auxiliary tank shall be not less than the volume of the measuring tank. The equipment shall be so arranged that the water pressure in the measuring tank cannot exceed that due to the difference in elevation between the two tanks. The measuring tank shall be equipped with an outside tap and valve to provide for checking the graduation on the indicator, unless other means are provided for readily and accurately determining the amount of water discharged. Means shall be provided to automatically stop the flow of water from the measuring tank when the desired quantity has been delivered. If the specified amount of water can be provided without the auxiliary tank, the auxiliary tank will not be required.

When measuring water by weight (mass), the requirement for the scale shall be as specified in Article 1103.02(c), the accuracy of measuring shall be as specified above, and means shall be provided for automatically stopping the flow of water into the weighing container at the moment the correct amount has been delivered. A water meter may be used for measuring water

provided it meets the requirements for automatic stop of the flow of water and accuracy of measurement.

Pickup and throw-over blades in the drum of the mixer which are worn down 3/4 in. (20 mm) or more in depth shall be replaced with new blades.

- (b) Truck Mixer. Truck mixers shall be either the type having a watertight revolving drum, suitably mounted and fitted with adequate blades attached to the drum, or the type having an open-top, watertight, trough-like container, suitably mounted and fitted with adequate blades revolving about an axis parallel to the axis of the trough. Truck mixers shall be capable of combining materials into a uniform mixture, and of discharging the mixture without segregation.

Truck mixer blades at the point of maximum drum diameter, nearest to the drum head, shall not be worn more than ten percent of the original radial height. The radial height shall be determined according to the National Ready Mixed Concrete Association's Certification of Ready Mixed Concrete Production Facilities/Plant Certification Check List document, the blade dimensions provided by the manufacturer, or other available information.

Truck mixers, except when used exclusively for agitating premixed concrete, shall be provided with a batch meter and locking device capable of preventing the discharge of the concrete before the required number of revolutions has been obtained, or with an approved revolution counter, suitably mounted, to provide a means of verifying the amount of mixing obtained.

The water measuring device shall be capable of measuring and discharging the specified amount of water within a limit of accuracy of one percent, except a limit of accuracy closer than 1 qt (1 L) will not be required. If the water is added during transit, the measuring device may be mounted upon the truck mixer, and an outside tap or valve shall be provided for checking the graduations on the indicator, unless other means are provided for readily and accurately determining the amount of mixing water discharged. Provisions shall be made to automatically stop the flow of water when the desired amount has been delivered. If not mounted on the truck mixer, the water measuring device shall be located at the site selected for adding the water, and shall be according to the requirements of Article 1103.01(a). A water glass placed vertically on the water tank shall not be used as a water measuring device, except for final slump adjustment at the job site.

The equipment for weighing and batching the materials for truck mixing shall be according to Article 1103.02.

The truck mixer shall be approved before use according to the Bureau of Materials and Physical Research's Policy Memorandum, "Approval of Concrete Plants and Delivery Trucks".

- (c) Truck Agitator. Truck agitators shall be either the type having a watertight revolving drum, suitably mounted and fitted with adequate blades attached to the drum, or the type having an open-top, watertight, trough-like

container, suitably mounted and fitted with adequate blades revolving about an axis parallel to the axis of the trough. The truck agitator, when fully loaded, shall be capable of maintaining the mixed concrete in a thoroughly mixed and uniform mass, and of discharging the concrete without segregation. For the open-top truck agitator, a watertight cover shall be used to protect the concrete when it is raining.

The truck agitator shall be approved before use according to the Bureau of Materials and Physical Research's Policy Memorandum, "Approval of Concrete Plants and Delivery Trucks".

- (d) Nonagitator Trucks. Nonagitator trucks shall have a metal container that is smooth, watertight, and non-reactive to concrete. Nonagitator trucks shall be capable of discharging the concrete at a satisfactorily controlled rate and without segregation. A watertight cover shall be used to protect the concrete when it is raining.

The nonagitator truck shall be approved before use according to the Bureau of Materials and Physical Research's Policy Memorandum, "Approval of Concrete Plants and Delivery Trucks".

1103.02 Batching and Weighing Equipment. The plant shall be approved before production begins according to the Bureau of Materials and Physical Research's Policy Memorandum, "Approval of Concrete Plants and Delivery Trucks". The bins, weighing hoppers and scales shall be arranged to the satisfaction of the Engineer so that the weigh beam "telltale" dial, or the dial scale, or the digital readout is in full view of the operator controlling the gates, valves or belts that feed the material into the weighing hopper. The equipment used for batching and weighing the materials shall comply with the following requirements.

- (a) Bins and Silos. Bins and silos shall have sufficient capacity for adequate supply of materials to the weighing hoppers. They shall be supported by rigid frame work on a safe foundation. Portable type bins and silos shall be fully loaded and permitted to stand for at least 12 hours before operations start. Bins and silos shall have separate compartments for each aggregate, cement, and finely divided mineral used. Except for permanently located plants, the top of the fine aggregate compartment shall be equipped with a tilted screening device which shall reject all material coarser than 1 in. (25 mm) and through which all fine aggregate must pass upon entering that compartment. Each compartment shall be designed to discharge material efficiently and freely into the measuring hopper.

Means of control shall be provided so that when the quantity to be obtained is being approached, the flow of the material can be gradually retarded and completely shut off, without leakage, at the moment the desired amount has been discharged.

- (b) Weighing Hoppers. The hoppers shall be completely suspended from the scales and shall otherwise hang free and, except as further provided, shall have sufficient capacity to contain the material or materials to be weighed for one batch without shoveling and without jiggling the hopper to keep bin gates and chute openings free of material during the weighing. Cement

shall be weighed in a hopper entirely free and independent of the hopper or hoppers used for weighing the aggregate. When manually batching, finely divided minerals shall be weighed in a separate hopper. Finely divided minerals may be weighed into the cement weigh hopper for automatic or semi-automatic batching.

Batching equipment, insufficient in capacity to weigh the materials required for a full batch, will be permitted for stationary mixers and truck mixers provided that the capacity of the hopper or hoppers is sufficient to weigh all the materials for at least 1 cu yd (0.75 cu m) of concrete for any mixer of rated capacity of 1 cu yd (0.75 cu m) or larger. The batching equipment shall be limited to a maximum of three weighings of each material for charging the mixer.

All hoppers, except cement, shall have a port or other opening for removal of overload of any one of the materials unless sufficient clearance for this purpose exists between the bottom of the bin gate and the top of the hopper. The top of the cement hopper shall be closed to prevent the escape of cement while it is being weighed. Hoppers shall be constructed in a manner that will eliminate the accumulation of tare material and leakage through the discharge gates during weighing. They shall be capable of discharging the material efficiently and completely into the batch trucks or mixer without the necessity of beating or jiggling. If any hopper, in the opinion of the Engineer, does not discharge the material satisfactorily, it shall be provided with a vibrator of sufficient frequency and power to assure complete discharge. For cement and finely divided minerals, a device shall indicate the complete discharge of materials. All weighing hoppers shall be enclosed or otherwise protected against wind.

- (c) Scales. The scales may be of either the horizontal beam or the springless dial type, shall be designed as an integral unit of the batching equipment, and shall be constructed to withstand the usage for which they are intended. Load cells with digital readouts may also be used.

Beam type scales shall have as many beams and of such capacities as will permit the required weight (mass) of each aggregate to be set off on a single beam, except that when one aggregate is required, two weigh beams will be permitted. The scale shall be provided with suitable lockouts so that the weigh beams may be engaged to weigh in the desired order. Each weigh beam shall have some means or device to indicate when the beam is in the proper balance position. Poises shall be constructed so that they will be held firmly in position. Beam scales shall have provisions such as a "telltale" dial for indicating to the operator that the required load in the hopper is being approached. Such device shall indicate at least the last 200 lb (90 kg) of load in the case of scales used for weighing aggregate, and at least the last 100 lb (45 kg) of load in the case of scales used for weighing cement and finely divided minerals, and shall be placed in a position from which it can be viewed without parallax by the operator while charging the hopper.

Except for permanently located plants, springless dial scales shall be provided with suitable markers inside the glass cover and in front of the dial which may be set to show the position of the dial indicator for the required

load or the various accumulative loads when more than one aggregate is weighed in the same hopper. Markers shall have distinctive colors for the various materials to be weighed. Dials shall be placed so that they can be viewed without parallax by the operator.

The value of the minimum graduation interval of any scale used for weighing materials shall be not more than 0.2 percent of the batch weight (mass) and not more than 0.1 percent of the capacity of the scale, except that graduation intervals less than 5 lb (2 kg) when weighing aggregates and less than 2 lb (1 kg) when weighing cement and finely divided minerals will not be required. In the case of beam scales, the same requirement shall also apply to the graduation of each individual beam with respect to the weight (mass) of material normally weighed on it. The value of the minimum graduation interval of any scale used for weighing mixing water shall be not less than 2 lb (1 kg). All scales shall be designed and built to a maximum tolerance of 0.4 percent of the net load in the hopper.

Cement shall be weighed on a scale separate and distinct from the scale or scales used for weighing other materials. Mixing water, when weighed, shall be subject to the same requirement as cement. Finely divided minerals shall be weighed on a separate scale unless the batching equipment is automatic or semi-automatic. When a beam scale is used for weighing cement, a tare beam shall be provided and the weigh beam or beams shall be capable of being lifted out of weighing position so that the tare weight (mass) of the hopper can be checked after each weighing operation to determine if all of the cement or finely divided minerals has been discharged into the batch.

Scales shall be housed or otherwise protected against the effect of wind in a manner meeting the approval of the Engineer.

The scales shall be calibrated by an independent company. The independent company shall have scale testing equipment and standard weights meeting the requirements of NIST. The scale calibration will be observed by the Engineer. Scales shall be calibrated at the beginning of each construction season or each 12 month period, and each time the scales are moved, or when scale components are repaired or replaced.

Once a scale is calibrated, the settings shall not be altered. The concrete producer shall submit for approval by the Engineer, a method to verify the settings have not been altered. If at any time the Engineer determines the settings have been altered, a new calibration will be required.

Means of access for inspection purposes shall be safe and shall meet the approval of the Engineer. In the case of permanently located plants, the means of access shall be an inclined stairway with the handrail located so that its upward flight will end on the scale operator's platform. It shall be firmly attached to the supporting members of the bin. The weigh platform shall have an approved floor of metal grid or 2 in. (50 mm) plank.

- (d) Slurry Mixer. A slurry mixer may be used to premix cement, finely divided minerals, water, and admixtures before discharge into a stationary mixer or truck mixer. The equipment shall be a vortex type, paddle type, or other

type approved by the Engineer. The vortex type shall have an impeller for mixing. The paddle type shall have mixing blades and paddles for mixing.

The batching equipment shall have a moisture sensor to measure the fine aggregate moisture, when the slurry mixer is operated. The cement, finely divided minerals, and water shall be measured in the slurry mixer, according to Article 1020.10. The mixing of materials in the slurry mixer shall result in a uniform mix, which shall flow into the stationary mixer or truck mixer.

The batching equipment shall have the ability to batch cement and finely divided minerals with or without the use of the slurry mixer.

1103.03 Automatic and Semi-Automatic Batching Equipment. Automatic equipment for weighing, measuring, batching and mixing materials shall be according to Articles 1103.01 and 1103.02, except as follows.

- (a) General Requirements. It is the purpose of the requirements set forth herein that automatic and semi-automatic batching equipment shall render impossible the omission of any one of the required materials from any batch, and that duplications of measurement of any one material into any batch shall not occur. Further, it is the intent that the amounts of materials entering into any batch shall be accurately measured within the specific tolerances set forth herein. In the case of stationary mixers, it is intended that each batch shall be mixed during the full period required after all the materials have entered the mixer, and that recharging the mixer shall not occur before the previous batch has been discharged. Certain requirements to further the objects stated are as follows.
 - (1) Allowable Tolerances. Aggregates measured individually or cumulatively, shall have a tolerance within $\pm 1\frac{1}{2}$ percent of the required quantity. Cement and cementitious materials measured individually or cumulatively, shall have a tolerance within ± 1 percent of the required quantity. Water shall be measured to a tolerance within ± 1 percent of the required quantity. Admixtures shall be measured to a tolerance within ± 3 percent of the required quantity. The interlock control shall be set to the required tolerance.
 - (2) Weighing Control. Arrangement shall be such that any scale of the system can be conveniently checked for accuracy at any time that this should be considered desirable. All scales shall be designed and built so that, when any drag due to weighing control devices is included, an accuracy within the maximum tolerance of 0.4 percent of the net load in the hopper will be maintained.
 - (3) Water Measuring Control. When the mixing water is measured volumetrically, provisions shall be made for bypassing the measured water into a container for checking the accuracy of delivery. If the water is measured during the course of its flow into the batch, means shall be provided to show, at any time during the flow, the amount that has entered. Devices for volumetric measurement of mixing water, in the case of automatic systems, shall automatically reset at the initial

position immediately after delivery of the measured amount, ready for the next succeeding batch cycle.

- (4) **Admixture Control.** The dispenser for an admixture shall meet the requirements for automatic or semi-automatic batching. Liquid admixtures shall be protected from freezing and contamination. Agitation shall be provided for liquid admixtures which are not stable solutions.

To provide a visual indication the liquid admixture is actually entering the batch, the tube conducting the admixture into the stream of mixing water or directly on the aggregate shall be transparent or translucent, or shall have a transparent or translucent section. If approved by the Engineer, an alternate indicator may be used for high range water-reducing admixtures and corrosion inhibitor admixtures.

The dispenser's visual indicator shall be easily viewed by the plant operator when batching. Televised images may be used.

- (5) **Control of Mixing Time.** When automatic or semi-automatic batching equipment, in connection with stationary mixers, are used for successive batches of the same size, the mixing time adjusting control shall be capable of being locked with a key.
- (b) **Automatic Batching Equipment.** Automatic batching equipment shall be provided with gates, valves, or other suitable devices, which, when activated by a single starting mechanism, shall set in motion the charging of weigh hoppers or other containers, and which, in weighing or measuring any given material, shall automatically stop the flow of that material when the desired amount, within the allowable tolerance, has been attained. Automatic batching equipment shall be capable of having quantities preset on a central control panel that will result in correct measurement of each material for each batch, and control adjustments shall be capable of being performed on that panel.

For any material measured by weight (mass), a suitable "over" and "under" indicating device shall be provided, showing whether the amount of material weighed is within the allowable tolerance. Interlock shall be provided (1) so that the charging device can open or start only when the scale indicates zero load and when the weigh hopper or container discharging gate or valve is closed, and (2) so that the discharging gate or valve can open only when the desired weight (mass) within the allowable tolerance is in the weigh hopper or container and when the charging device is closed or stopped. If more than one aggregate is weighed cumulatively into the same hopper, control and interlock shall be provided with respect to each increment of weighing, as required for a material weighed into an individual hopper. It shall not be mandatory that the mixing water and air-entraining admixture be measured by weighing. These materials may be measured volumetrically, if the specified controls, or other equally effective means are provided, and if the measurements are within the specified tolerance.

Automatic batching equipment for weighing or measuring batch quantities in increments shall be provided with an automatic repeater having a counter that can be set for the number of increments required, and which shall ensure that the required number of increments are accurately delivered and discharged into each batch.

An automatic batching system shall consist of the combination of automatic batchers necessary for batching the materials required. All shall be activated by a single starting mechanism and the system shall be completely interlocked. In the case of stationary mixers, interlock shall be provided so that the discharging gates or valves can open only when the mixer is in the proper position for receiving the materials. The interlock of the system, with respect to sequence of discharge of the materials into the mixer, shall be such that the mixing water and air-entraining admixture are discharged according to the requirements of Articles 1020.08 and 1020.11.

Means shall be provided for convenient adjustment, from preset quantities, of the amounts of the aggregates, the mixing water and the air-entraining admixture, as based on tests of the aggregates and observations and tests of the mixture being produced. Suitable equipment indicating the amount of free water in the fine aggregate, as it is being batched, shall be provided, and the quantities of fine aggregate and mixing water shall be adjusted currently, as concrete is being produced, so that the desired amounts of these materials enter into each batch. Other adjustments of the quantities, as preset for automatic control, shall be made only at the direction of the Engineer.

The operator shall not interfere with the operation of any part of the scale mechanism during the weighing process for the purpose of circumventing the interlock or malfunction of the equipment. Failure to comply with this requirement shall be cause for the Engineer to require that the equipment be provided with a positive means for preventing such interference.

A batching system consisting of a combination of semi-automatic batchers, as described below, and automatic batchers may be approved, provided that control and interlock shall be as prescribed for automatic batchers.

- (c) Semi-automatic Batching Equipment. Batching equipment which does not substantially comply with all the requirements prescribed for automatic batching equipment, but which meets at least the following described minimum conditions, will be considered as semi-automatic batching equipment.

As a minimum requirement, semi-automatic batching equipment shall be provided with gates, valves or other suitable devices, which open or start separately, when actuated by individual starting mechanisms, to permit the material to be weighed or measured, and close or stop automatically when the desired amount, within the allowable tolerance, has been attained. Interlock with respect to individual units and "over" and "under" indicating devices shall be provided as prescribed for automatic batching equipment.

Other features prescribed for automatic batching equipment may be incorporated and approved.

A semi-automatic batching system shall consist of the combination of semi-automatic batchers necessary for batching the materials required. The system may be partially or completely interlocked.

For semi-automatic batching systems constructed so that materials are batched at more than one stop or location, a separate control panel shall be furnished at each location, unless the operations can be controlled from a central location in a manner that will ensure that the correct amount of material is included in each batch. In the event that movement of trucks receiving the batches is necessary during the operations at any location, a separate control panel shall be provided at that location, and an operator shall be present to ensure that the batches are discharged correctly into their respective compartments. However, if effective interlock is provided between the movement of trucks and the batching mechanism so that batches can be discharged only as required without omission or duplication, and as each batch compartment is brought into correct position, then the operations may be conducted from a centrally located control panel.

The operator shall not interfere with the operation of any part of the scale mechanism during the weighing process for the purpose of circumventing the interlock or malfunction of the equipment. Failure to comply with this requirement shall be cause for the Engineer to require that the equipment be provided with a positive means for preventing such interference.

A batching system consisting of a combination of semi-automatic and manual batchers may be approved, provided that satisfactory control of the batching is attained.

- (d) Manual Operation. Automatic and semi-automatic batching equipment may be constructed so that they can be switched to manual control. When switching to manual control is necessary, the batching operations shall continue only until repairs can be made, but not for a period exceeding 72 hours, unless otherwise approved by the Engineer.

If provision is made for switching to manual operation, then the scale, or a scale follower approved by the Engineer, shall be placed within easy view of the operator, but not farther than 20 ft (6 m) from the location from which the manual batching is being performed. Dial scales shall be placed so that they can be viewed without parallax.

1103.04 Mobile Portland Cement Concrete Plants. The mobile concrete plant shall meet the following minimum requirements.

- (a) The mixer shall be capable of carrying sufficient unmixed materials to produce not less than 6 cu yd (4.6 cu m) of concrete.
- (b) The mixer shall be capable of positive measurement of cement being introduced into the mix. A recording meter visible at all times and equipped with a ticket printout shall indicate this quantity.

- (c) The mixer shall provide positive control of the flow of water into the mixing chamber. Water flow shall be readily adjustable for variations in aggregate moisture.
- (d) The mixer shall be capable of being calibrated to automatically proportion and blend all components on a continuous or intermittent basis, as required by the finishing operation, and shall discharge mixed material through a conventional chute.
- (e) The mixer shall be calibrated annually by a commercial testing laboratory. Copies of calibration charts shall be maintained in the truck and also the District office.
- (f) The mixer shall be maintained clean and in good repair.
- (g) The mixer shall meet all requirements of AASHTO M 241.

1103.05 Forms. Forms for pavement, concrete gutter, curb, median and paved ditches shall be as follows.

- (a) Pavement. Flexible or curved forms of proper radius, made of either metal or wood, shall be supplied for use on curves of 100 ft (30 m) radius or less.

At all other locations, unless approved by the Engineer, side forms for pavement shall be metal. They shall be of an approved cross section, and shall be furnished in sections not less than 10 ft (3 m) in length. They shall have a height not less than the edge thickness of the pavement to be constructed, a base width equal to or greater than the height and shall be made of metal not less than 1/4 in. (6 mm) in thickness, except that a minimum thickness of 3/16 in. (5 mm) will be permitted if the form is of trapezoidal cross section. They shall have flange braces extending outward on the base not less than 2/3 the height of the form and spaced not more than 5 ft (1.5 m) apart. Each section shall have a steel pin at each end and at least one intermediate pin, and provision shall be made to lock all pins to a true grade. Locked joints shall be provided between form sections to maintain the alignment and elevation of the form line. Metal forms shall withstand loading imparted by the paving train without distortion or settlement of the form line. They shall be straight and free from warp. Any form varying on its upper edge more than 1/16 in. in 10 ft (2 mm in 3 m) from a straight line will be rejected. The longitudinal axis of the upstanding leg shall not vary more than 1/4 in. in 10 ft (6 mm in 3 m) from a straight line.

The use of wood forms will not be permitted unless approved by the Engineer. When used, wood forms shall be made of well seasoned, surfaced plank, shall be not less than 2 in. (50 mm) thick (commercial dimensions), with the exception of curved or flexible sections, and shall be the full depth of the concrete slab; shall be straight and free from warp; shall provide for rigid, smooth connections; and shall provide ways and means to be securely fastened in place to the lines and grades given.

Metal forms that will be used to support a vibrating screed shall be made of no less than 10 gauge (3.4 mm) steel with a minimum 4 in. (100 mm) wide base and have a minimum of two flange braces with provisions for pin locking in each 10 ft (3 m) section.

Metal pins shall be of proper size and length to hold the forms rigidly and securely in place.

Metal forms may be built-up with a single layer of wood plank, 2 in. (50 mm) thick or less when the specified pavement thickness differs from standard manufactured form sizes. The wood plank shall be well seasoned surfaced hardwood free from warp and twist. The plank shall be attached to the bottom of the metal form with two lines of bolts at not more than 2 ft (600 mm) centers on each line. The width of the plank shall equal or exceed the pavement thickness.

- (b) Concrete Gutter, Curb, Median and Paved Ditch. The forms shall be of wood or metal, straight and free from warp, and of sufficient strength to resist springing during the process of depositing the concrete against them. Wood forms shall consist of 2 in. (50 mm) surface plank, except wood forms less than 2 in. (50 mm) thick may be used for short radii. Metal forms shall be of an approved section and shall have a flat surface on the top. Forms shall be so designed that divider plates or other devices for holding the form in place will not cause planes of weakness in the concrete and subsequent cracking. The forms shall be of a depth of the curbing, median or paved ditch, and so designed as to permit secure fastening together at the tops.

1103.06 Reserved.

1103.07 Reserved.

1103.08 Subgrade Planer. The subgrade planer shall be of steel and be mounted on rollers or wheels. It shall be equipped with steel cutting edges or cutting rollers, so designed that they may be accurately adjusted vertically. The subgrade planer shall be of sufficient weight (mass) so as not to rise from the pressure of the material being planed. The subgrade planer shall produce a cross section in accordance with the plans and shall not develop a center deflection of more than 1/8 in. (3 mm).

1103.09 Subgrade Machine. The subgrade machine shall be self-propelled and mounted on crawler type tracks. It shall be equipped with a rotating drum fitted with cutting teeth capable of cutting and trimming earth, aggregate and hot-mix asphalt, and so designed that they may be accurately adjusted vertically and held in place. The machine shall have a moldboard to provide the final surface and texture. It shall weigh not less than 7000 lb (3200 kg) and shall have such strength and rigidity that it will not develop a center deflection of more than 1/8 in. (3 mm).

The subgrade machine shall be equipped with an automatic electronic grade control device. The device shall be capable of controlling the elevation of the subgrade machine relative to either a preset grade control stringline or a traveling grade reference. The method of grade control shall be approved by the Engineer.

1103.10 Reserved.

1103.11 Water Supply Equipment. The water supply equipment shall be of such capacity and design as to ensure an ample supply and adequate pressure simultaneously for all of the requirements of machinery, mixing, curing, wetting subgrade, and all other features of the work.

1103.12 Mechanical Concrete Spreader. The mechanical concrete spreader shall be approved by the Engineer. The spreader shall run on forms when forms are used or on wheels or tracks when slip forming. The mechanical concrete spreader shall be self-propelled and shall be capable of spreading the concrete mix to the desired cross sections. The spreader shall be easily adjustable to spread different elevations of concrete. Vibrators may be attached to the spreader, finishing machine or may be mounted on a separate carriage and shall avoid contact with the joints, load transfer devices, reinforcement, subgrade, subbase, or side forms.

The vibrating impulses shall be applied through an apparatus especially designed for this purpose and so constructed as to operate satisfactorily ahead of the finishing machine in such a manner that the vibratory impulses are transmitted through the concrete mass with sufficient intensity to consolidate it throughout its entire depth and width. Vibrators shall be used only for purposes of consolidation.

Surface pan type vibrators shall be so designed that the vibrating impulses will be applied directly to the surface of the concrete. The surface pan type vibrator shall be equipped with a minimum of two vibrating elements for each lane width of pavement vibrated. The operating frequency shall be 3500 VPM or greater.

Vibrators of the internal type shall be especially designed for this purpose and so constructed as to operate satisfactorily. The operating frequency of the internal type shall be 7000 +/- 2000 VPM. The vibrating elements shall be so spaced that the concrete mass shall be consolidated throughout its entire depth and width, but the spacing of the vibrating elements shall be 24 in. (600 mm) or less.

A vibrating reed tachometer, hand type, shall be provided with each paver. The vibrating reed tachometer shall have a range from at least 4000 to 10000 VPM.

For a contract which has a minimum of 10,000 sq yd (8350 sq m) of pavement that is 12 ft (3.6 m) or more wide, an electronic internal vibrator monitoring device shall be provided. The device shall be capable of displaying the operating frequency of each internal vibrator, and shall be visible to the paving operator. The vibrator monitoring device shall have a range from at least 4000 to 10,000 VPM.

1103.13 Finishing Machine. Finishing machines for portland cement concrete bridge decks and pavement shall be according to the following.

- (a) Bridge Deck. The finishing machine shall be equipped with: (1) a mechanical strike off device; (2) either a rotating cylinder(s) or a longitudinal oscillating screed which transversely finishes the surface of the concrete; and (3) fogging equipment. The Contractor may attach other equipment to the finishing machine to enhance the final finish when approved by the Engineer. The finishing machine shall produce a floor surface of uniform texture, free from porous areas, and with the required surface smoothness.

The finishing machine shall be operated on rails or other supports that will not deflect under the applied loads. The supports shall be adjustable for elevation and shall be completely in place for the full length of the area to be finished. The supports shall be approved by the Engineer before placing of the concrete is started.

- (b) Pavement. Finishing machines for pavement shall be according to the following.

- (1) The finishing machine shall be designed for concrete paving and meet the approval of the Engineer. The finishing machine shall be power driven with at least two oscillating screeds or a pan type screed which shall be capable of placing, spreading, consolidating, screeding, and finishing the concrete to the proper pavement elevation and cross section within the specified tolerance.

The pan type paver shall be equipped with augers, strike off and tamper bars ahead of the pan screed with at least one trailing oscillating screed or belt finisher. The pan shall be sufficiently braced and stiffened to ensure no deflection. Internal vibrators with pressure compensating controls meeting the requirements of Article 1103.12 shall be attached to the paver. If the paver is powered by cable and motor, a steering sensor shall be required and the motor shall be hydraulically operated. One switch or control, which stops or starts all paver functions simultaneously, shall be provided.

- (2) Other types of power driven finishing machines, exclusive of vibratory screeds and truss-type vibratory screeds, which are specifically designed for finishing concrete pavement or bridge decks and meet the approval of the Engineer, may be used under the following conditions.

- a. Restricted clearance outside the forms.
- b. Mainline pavements with a posted speed of less than or equal to 40 mph.
- c. Where a continuous line of forms more than 600 ft (180 m) cannot be set. Railroad tracks, bridges, existing paved intersections, or gaps shown in the plans or ordered by the Engineer shall be considered as obstructions in the continuity of the form line.
- d. Bridge approach pavement, shoulder pavements, and connections.

The use of a mechanical concrete spreader may be waived provide the concrete hauling equipment is equipped with a discharge system capable of distributing the concrete uniformly without segregation across the subgrade or subbase.

1103.14 Concrete Finisher Float. The concrete finisher float shall be either self-propelled or attached to a finishing machine. The float shall be easily adjustable from crown to flat. The float shall be a minimum of 30 in. (750 mm) in length with a

minimum of 24 in. (600 mm) in contact with the concrete. It shall be so designed to prevent tearing of the concrete surface or rolling of aggregate under the float. The float pan shall be suspended from the frame, float freely on the concrete, and shall be capable of being adjusted in both height and width. The float pan, once adjusted, shall be equipped hydraulically or by other suitable means that it may be raised from the operator's platform and when lowered shall automatically return to its preset position. If self-propelled, it shall also be equipped with four or more wheels which ride on the forms and it shall be of sufficient weight (mass) as to resist flexing under the pressure of the concrete.

1103.15 Mechanical Longitudinal Float. The machine shall be so constructed that the travel of the floating mechanism can be adjusted to conform to the pavement cross section, elevation, and surface smoothness shown on the plans. The float shall be a minimum of 10 ft (3 m) in length and 1 ft (300 mm) in width. It shall be equipped with a power driven floating screed and shall oscillate longitudinally with respect to the pavement during its transverse travel across the pavement. It may be either attached to the finishing machine or formless paver, self propelled on rollers operating on forms or self propelled operating on tracks. If attached to a finishing machine or formless paver, it shall be rigidly supported by a frame at the rear in a manner approved by the Engineer. If self propelled, the tracks or rollers from which the float operates shall be in good working condition. The tracks or rollers from which the float operates shall be accurately adjusted and coordinated with the adjustments of the finishing machine or formless paver so that a small amount of mortar is carried ahead of the float at all times.

1103.16 Formless Paver. The formless paver shall be self-propelled and equipped with suitable devices for spreading, strike off, consolidation, and finishing of concrete the full-width and depth as shown on the plans without the use of fixed side forms. The tracks shall be of sufficient length and width to properly support the machine and its load without causing excessive depressions. The formless paver shall be equipped with strike off screed, and internal vibrators of sufficient quantity to provide complete consolidation regardless of the depth of concrete placed. Vibrators shall meet the requirements of Article 1103.12. The paver shall be capable of constructing pavement to line and grade specified. The method of placing the concrete in front of the formless paver shall be a separate operation as specified in Article 1103.12 without being attached to the formless paver.

The formless paver shall be approved by the Engineer prior to starting the paving operations.

1103.17 Miscellaneous Equipment. Miscellaneous equipment shall be as follows.

- (a) Hand Vibrator. The vibrator shall be the internal type. It shall be adequately powered to operate under full load at a frequency of 4500 VPM or greater; and shall have an intensity and period of vibration sufficient to obtain thorough consolidation of the concrete.

The vibrator shall have a non-metallic head for areas containing epoxy coated reinforcement. The head shall be coated by the manufacturer. The hardness of the non-metallic head shall be less than the epoxy coated

reinforcement, resulting in no damage to the epoxy coating. Slip-on covers will not be allowed.

- (b) Hand Tamper. Hand tampers, when required or permitted under these Specifications, shall meet the approval of the Engineer.
- (c) Header. The header shall be shaped to conform to the cross section required by the plans. It shall be wood or metal and of sufficient thickness and rigidity to provide a vertical construction joint. The header for continuous reinforced pavement shall be of wood or metal and shall be split longitudinally to provide for the proper depth of the continuous reinforcement steel according to the plans.
- (d) Foot Bridge. Foot bridges shall be durably constructed and readily movable. They shall be so designed that no part of the bridge will come in contact with the pavement at any time. Two or more foot bridges shall be provided.
- (e) Hand-Operated Longitudinal Float. The hand-operated longitudinal float shall be at least 10 ft (3 m) in length and properly stiffened to prevent flexibility and warping during the finishing operation. The handle shall be at least 3 ft (1 m) longer than 1/2 the width of the slab.
- (f) Long-Handled Float. The long-handled float shall have a blade at least 3 ft (1 m) in length and 6 in. (150 mm) in width. The handle shall be of such length as will permit the operation of the float from the shoulder. Two or more such floats shall be provided.
- (g) Vibrating Screed. The screed used to strike off and consolidate the concrete by the hand method shall be durably constructed, equipped with a vibrator, and shall be shaped to provide the cross section as shown on the plans. The screed shall be at least 2 ft (600 mm) longer than the maximum width of the slab to be struck off. It shall be an approved design and be constructed either of metal or of other suitable material shod with metal.
- (h) 10 ft (3 m) Straightedge. The 10 ft (3 m) straightedge shall be made of suitable material, and shall be maintained in accurate alignment at all times. It shall be equipped with a handle at least 3 ft (1 m) longer than 1/2 the width of the slab. Two or more 10 ft (3 m) straightedges shall be provided.
- (i) Broom. Brooms shall be of push broom type, at least 18 in. (450 mm) in width. They shall contain a maximum of three rows of good quality bass or bassine fiber 4 1/2 in. (115 mm) or less in length. The handle shall be at least 1 ft (300 mm) longer than 1/2 the width of the slab and shall be readily adjustable. Two or more brooms shall be provided.
- (j) Edging Tool. The edging tools shall have a radius of 1/4 in. (6 mm), and shall be approved by the Engineer. Two or more edging tools shall be provided.
- (k) Fogging Equipment. Fogging equipment shall consist of a mechanically operated, pressurized system using a triple headed nozzle or an equivalent nozzle. The fogging nozzle shall be capable of producing a fine fog mist that

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will increase the relative humidity of the air just above the fresh concrete surface without accumulating any water on the concrete. The fogging equipment shall be mounted behind the roller and pan of finishing machine or on a separate foot bridge. Controls shall be designed to vary the volume of water flow, be easily accessible and immediately shut off the water when in the off position. Hand held fogging equipment will not be allowed.

SECTION 1104. CEMENT OR POZZOLANIC AGGREGATE MIXTURE EQUIPMENT

1104.01 Mixing Plant. The cement or pozzolan aggregate mixture plant shall be a batch or continuous type mixing plant. The plant units shall be so designed, coordinated, and operated that they will produce mixtures within the tolerances specified. The plant units shall meet the following requirements.

- (a) General. All plants shall be approved by the Department before production begins. Plants not meeting the conditions herein specified may, upon request, be granted a conditional waiver to operate, provided satisfactory evidence is presented that the required modifications are in progress. This conditional waiver will be terminated on November 1 of the year in question and shall not be renewed for any succeeding year.
- (b) Safety, Calibration, Inspection Requirements. The plant shall be equipped with safe, unobstructed walkways and stairways, to all sampling points and the mixer platform. Accessibility to the top of the truck bodies shall be provided by a platform or other suitable device. All gears, pulleys, chain sprockets and other dangerous moving parts shall be equipped with guards. Suitable devices shall be provided to enable the Engineer to obtain samples, raise scale calibration equipment, sampling equipment or other equipment from the ground to points of sampling.
- (c) Laboratory. Each plant shall be provided with a laboratory, equipped to perform such tests as are necessary for quality control or assessment of the mixture. This laboratory shall be located in the same building as the plant operator, or in a separate building located within 200 ft (60 m) of the plant operator.

Each laboratory shall be provided with adequate lighting, heating, air conditioning, electrical outlets (110 V service), running water, and a telephone. Furnishings shall include a desk, chair, sink and 3 x 3 x 10 ft (0.9 x 0.9 x 3 m) work bench. Safety and sanitary facilities, including fire extinguisher, first-aid equipment and toilet facilities shall be available on the premises.

The following testing equipment shall be furnished by the producer as part of the laboratory facilities:

- 1 balance capacity of 0-2500 g complete with appropriate weights
- 1 set of sieves, 8 in. (200 mm) diameter, consisting of the following sizes:

1 1/2 in. (37.5 mm), 1 in. (25.0 mm),

1/2 in. (12.5 mm), 3/8 in. (9.5 mm),
 No. 4 (4.75 mm), No. 8 (2.36 mm),
 No. 10 (2.00 mm), No. 40 (425 μ m),
 No. 200 (75 μ m), complete with pan and cover.

1 mechanical sieve shaker and timer.

1 oven with controllable temperature from 73 ± 2 °F to 230 ± 9 °F
 (23 ± 1 °C to 110 ± 5 °C)

1 small sample splitter, riffle type, complete with pans.

1 large sample splitter, riffle type, complete with pans.

1 compaction base as required in AASHTO T 180, Article 4.2.

- (d) **Storage Facilities.** Sufficient space shall be provided for storage of each ingredient material type. If necessary to prevent the intermixing of the different materials in adjacent stockpiles, suitable partitions shall be used between the stockpiles. All aggregates shall be kept separated until they are fed in their proper proportions onto a belt conveyor. Aggregates shall be handled in such a manner as to prevent contamination and degradation. Lime, cement, or fly ash shall be stored separately in such a manner that caking, cementing and bulking due to moisture will be minimized prior to introduction into the mix. Storage bins, silos or compartments shall be equipped with warning devices at the lower 1/4 points, which will visually or audibly alert the operator, during production, of a low level condition. A scalper or other device that will remove large lumps of clay, aggregate or fly ash shall be installed at the top of fly ash and aggregate bins.
- (e) **Crane or End Loader.** The crane used in stockpiling the aggregates or conveying the aggregates to the aggregate feeders shall be in good mechanical condition. When compartment aggregate bins are used, the width of the crane bucket shall be not more than one-half the minimum width of the top of the bin compartments, and the maximum length of the bucket when fully open shall be at least 1 ft (300 mm) less than the length of the top of the bin compartment or extensions.

When an endloader is used to charge bins, the maximum discharge width of the bucket shall be 2 ft (600 mm) less than the width of the top of the bin.

- (f) **Calibration/Calibration Checks of Lime, Fly Ash, Cement, and Aggregate Feeds.** Initial calibration of aggregate and/or fly ash shall be accomplished separately, by weighing truckload increments discharged through the mixer. Provision shall be made for diversion of lime in smaller increments acceptable to the Engineer, into appropriate test weight containers, prior to introduction into the mixer.

Calibration checks during production may be performed in smaller quantities, acceptable to the Engineer, of each or all components. Plants equipped with weight belts, for any or all mix ingredients, will require diversion and/or separate weighings of ingredients only during initial calibration, unless required as a result of scale repair or readjustment. Feeders for each ingredient shall be equipped with revolution counters, mechanically connected to a shaft. Calibration and spot checks of all

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components shall be performed under normal operating conditions of belt speed, and bin or silo head.

The plant shall be equipped to handle and weigh test weight samples and containers. Platform scales of capacity up to 350 lb (160 kg), for weighing lime and check calibration samples shall be of certified accuracy, or otherwise checked for accuracy in the presence of the Engineer using 50 lb (25 kg) test weights. The Contractor (producer) shall also provide truck scales of certified accuracy for weighing of truckload increments.

- (g) Proportioning of Lime, Fly Ash, Cement and Aggregate. The plant shall be equipped with accurate means of feeding, by weight (mass) or volume such amounts of lime, fly ash, cement and aggregate(s) as are required by the mixing formula and within those tolerances specified for pozzolan aggregate and cement aggregate mixtures. If proportioned volumetrically, each ingredient bin or compartment shall have an accurately controlled gate which shall be bolted or otherwise fixed in position during plant operation. If proportioned by weight (mass), each ingredient feed shall be mechanically or electrically controlled so as to automatically maintain present feed rates.

Provisions shall be made so that complete malfunction of any single component feed will initiate an audible or visual warning to the operator until such deficiency is corrected. Warning override shall be effected only for the purpose of mixer clean-out during plant operation.

- (h) Mixing Water. Water may be proportioned either by weight or volume. An appropriate indicator reading in gal/min (L/min) or lb/min (kg/min) visible to the operator shall continuously indicate the rate at which water is being discharged into the mixture.
- (i) Mixer. The plant shall include a continuous or batch mixer capable of producing a uniform mixture within the job-mix tolerances. Continuous mixers which discharge directly into trucks shall be equipped with discharge/surge hoppers large enough to permit changing trucks without shutting down the plant.

Mixers discharging into surge silo transfer conveyors or elevators will not be required to have discharge hoppers. Mixer paddles shall be adjustable or reversible, to advance or retard mixture flow. If, in the opinion of the Engineer, adequate mixing is not being obtained, the Engineer may require that an adjustable baffle or dam, which can be locked or bolted in position, shall be installed at the discharge end of the mixer. The mixer shall have attached, a manufacturer's plate giving the net volumetric contents of the mixer at several depths.

- (j) Platform Truck Scale for Weighing Cement or Pozzolan Aggregate Mixtures. Cement or pozzolan aggregate mixtures shall be measured on platform scales according to Article 1102.01(a)(9).

SECTION 1105. PAVEMENT MARKING EQUIPMENT

1105.01 Thermoplastic. The material shall be applied to the pavement by an extrusion method where one side of the shaping-die is the pavement or by means of an extended ribbon. If used, the shaping-die should be equal to the width of the line specified in the plans. The method used shall produce sharp edges on both sides and square ends on each stripe. The use of pans, aprons, or similar devices to prevent die overruns will not be permitted.

The Contractor shall provide an accurate temperature measuring device capable of measuring the pavement temperature prior to installation of the thermoplastic and the temperature of the molten thermoplastic material immediately after it is applied.

- (a) **Truck-Mounted.** The equipment shall be permanently mounted on a truck of sufficient size and stability with an adequate power source to insure smooth, straight application and capable of maintaining a continuous operating speed of at least 3 mph (5 km/hr). The truck shall be equipped to carry a minimum of 4,000 lb (1,800 kg) of molten thermoplastic. The mounting shall allow the extrusion equipment to accurately follow road irregularities and produce lines of uniform dimensions. The equipment shall have a metering device to register the accumulated installed quantities for each gun, each day. Each vehicle shall include at least one operator who shall be a technical expert in equipment operations and thermoplastic application techniques. Certification of equipment shall be provided at the preconstruction conference.

The application equipment shall be capable of automatically placing intermittent and continuous lines of the various widths and colors of pavement marking lines specified.

- (b) **Hand-Operated.** The Engineer may permit the use of a hand-operated machine for those locations where only a limited quantity of lane and edge lining is required. Words, symbols, and lines other than edge lines may be placed with a hand-operated machine capable of containing a minimum of 125 lb (55 kg) of molten material. For the purpose of these specifications, "hand-operated" shall also include any riding units not considered as "truck-mounted".

1105.02 Epoxy. The epoxy pavement marking compounds shall be applied through machinery designed to precisely meter the two components in the ratio of 2:1. This equipment shall produce the required amount of heat at the mixing head and gun tip and maintain those temperatures within the tolerances specified. This machinery shall also have as an integral part of the gun carriage, a high pressure air spray capable of cleaning the pavement immediately prior to the marking application.

The equipment shall be capable of spraying both yellow and white epoxy, according to the manufacturer's recommended proportions and be mounted on a truck of sufficient size and stability with an adequate power source to produce lines of uniform dimensions and prevent application failure. The truck shall have at least two epoxy tanks each of 110 gal (415 L) minimum capacity and be equipped with hydraulic systems and agitators. It shall be capable of placing stripes on the left and

right sides and placing two lines on a three-line system simultaneously with either line in a solid or intermittent pattern, in yellow or white, and applying glass beads by the double drop pressurized bead system at a rate of 10 lb/gal (1.2 kg/L). All guns shall be in full view of operators at all times. The equipment shall have a metering device to register the accumulated installed quantities for each gun, each day. Each vehicle shall include at least one operator who shall be a technical expert in equipment operations and epoxy application techniques. Certification of equipment shall be provided at the preconstruction conference.

1105.03 Polyurea. The polyurea pavement marking compounds shall be applied through equipment specifically designed to apply two-component liquid materials, glass beads and/or reflective elements in a continuous and skip-line pattern. The two-component liquid materials shall be applied after being accurately metered and then mixed with a static mix tube or airless impingement mixing guns. The static mixing tube or impingement mixing guns shall accommodate plural component material systems that have a volumetric ratio of 2 to 1 or 3 to 1. This equipment shall produce the required amount of heat at the mixing head and gun tip and maintain those temperatures within the tolerances specified. The guns shall have the capacity to deliver materials from approximately 1.5 to 3 gal/min (5.7 to 11.4 L/min) to compensate for a typical range of application speeds of 6 to 8 mph (10 to 13 km/h). The accessories such as spray tip, mix chamber, and rod diameter shall be selected according to the manufacturer's specifications to achieve proper mixing and an acceptable spray pattern. The application equipment shall be maneuverable to the extent that straight lines can be followed and normal curves can be made in a true arc. The equipment shall also have as an integral part of the gun carriage, a high pressure air spray capable of cleaning the pavement immediately prior to making application.

The equipment shall be capable of spraying both yellow and white polyurea, according to the manufacturer's recommended proportions and be mounted on a truck of sufficient size and stability with an adequate power source to produce lines of uniform dimensions and prevent application failure. The truck shall have at least two polyurea tanks each of 110 gal (415 L) minimum capacity and be equipped with hydraulic systems and agitators. It shall be capable of placing stripes on the left and right sides and placing two lines on a three-line system simultaneously with either line in a solid or intermittent pattern, in yellow or white, and applying the appropriate reflective media according to manufacturer's recommendations. All guns shall be in full view of operations at all times. The equipment shall have a metering device to register the accumulated installed quantities for each gun, each day. Each vehicle shall include at least one operator who shall be a technical expert in equipment operations and polyurea application techniques. Certification of equipment shall be provided at the pre-construction conference.

The mobile applicator shall include the following features.

- (a) **Material Reservoirs.** The applicator shall provide individual material reservoirs, or space for the storage of Part A and Part B of the resin composition.
- (b) **Heating Equipment.** The applicator shall be equipped with heating equipment of sufficient capacity to maintain the individual resin components

at the manufacturer's recommended temperature of $\pm 5^{\circ}\text{F}$ ($\pm 2.8^{\circ}\text{C}$) for spray application.

- (c) Dispensing Equipment. The applicator shall be equipped with glass bead and/or reflective element dispensing equipment. The applicator shall be capable of applying the glass beads and/or reflective elements at a rate and combination indicated by the manufacturer.
- (d) Volumetric Usage. The applicator shall be equipped with metering devices or pressure gauges on the proportioning pumps as well as stroke counters to monitor volumetric usage. Metering devices or pressure gauges and stroke counters shall be visible to the Engineer.
- (e) Pavement Marking Placement. The applicator shall be equipped with all the necessary spray equipment, mixers, compressors, and other appurtenances to allow for the placement of reflectorized pavement markings in a simultaneous sequence of operations.

The Contractor shall provide an accurate temperature-measuring device(s) that shall be capable of measuring the pavement temperature prior to application of the material, the material temperature at the gun tip, and the material temperature prior to mixing.

SECTION 1106. WORK ZONE TRAFFIC CONTROL DEVICES

1106.01 Signs. Sign faces shall consist of retroreflective sheeting with the appropriate screened message. The retroreflective sheeting shall consist of glass spherical lens elements or plastic micro-prismatic elements covered with a transparent plastic film having a smooth, sealed surface, except that a rectangular pattern may be embossed into the film. The sheeting shall be weather resistant.

At the time of manufacturing, the retroreflective sheeting shall have the following initial minimum coefficient of retroreflection expressed as average candelas/foot candle/sq ft (candelas/lux/sq m) of material. Measurements shall be conducted according to ASTM E 810.

Initial Minimum Coefficient of Retroreflection candelas/foot candle/sq ft (candelas/lux/sq m) of material				
Color	Observation Angle = 0.2 degree Entrance Angle =		Observation Angle = 0.5 degree Entrance Angle =	
	-4 degrees	+30 degrees	-4 degrees	+30 degrees
Red	45.0	25.0	15.0	10.0
Silver/White	90.0	40.0	41.0	21.0
Yellow	60.0	30.0	25.0	13.0
Fluorescent Orange	100.0	30.0	40.0	15.0

The sheeting color shall conform to the appropriate standard color tolerance chart issued by the U.S. Department of Transportation, Federal Highway Administration. Orange signs shall be fluorescent orange in color.

The sheeting surface shall be smooth and flat, easily cleaned, have satisfactory wet performance, and exhibit an 85 degree gloss-meter rating of not less than 40 when tested according to the Test for Specular Gloss, ASTM D 523. The sheeting surface shall be readily processed and compatible with recommended transparent and opaque process inks and show no loss of the color coat with normal handling, cutting, and applications.

Sign sheeting shall be mounted on materials such as aluminum, rigid plastic, or exterior grade plywood. Signs utilizing a base of fabric, fiberboard, or other highly flexible or frangible material will not be permitted, except signs having a reflective sheeting face bonded to a durable plastic or fabric base will be permitted, (a) in work zones with posted speeds above 45 mph (70 km/hr) when workers are present to maintain the devices and (b) in all work zones having posted speeds of 45 mph (70 km/hr) or less.

Specific requirements for various signs shall be as follows.

- (a) Work Zone Speed Limit Signs. Work zone speed limit sign assemblies shall be as shown on the plans. The individual signs that make up an assembly may be combined on a single panel.
- (b) Flagger Traffic Control Paddle. The "STOP" face shall consist of white letters and border on a red background. The "SLOW" face shall consist of black letters and border on a fluorescent orange background. Areas outside sign borders shall be light blue or black. The portion of the staff within the sign face shall match the sign colors.

The staff may consist of two sections joined by a coupling.

1106.02 Devices. Work zone traffic control devices and combinations of devices shall meet FHWA crashworthiness standards for their respective categories. The categories are as follows.

Category 1 includes small, lightweight, channelizing, and delineating devices that have been in common use for many years and are known to be crashworthy by crash testing of similar devices or years of demonstrable safe performance. These include cones, tubular markers, flexible delineators, and plastic drums with no attachments. Category 1 devices shall be crash tested and accepted or may be self-certified by the manufacturer.

Category 2 includes devices that are not expected to produce significant vehicular velocity change but may otherwise be hazardous. These include drums and vertical panels with lights, barricades, and portable sign supports. Category 2 devices shall be crash tested and accepted for Test Level 3.

Category 3 includes devices that are expected to cause significant velocity changes or other potentially harmful reactions to impacting vehicles. These include crash cushions (impact attenuators), truck mounted attenuators, and other devices

not meeting the definitions of Category 1 or 2. Category 3 devices shall be crash tested and accepted for either Test Level 3 or the test level specified.

Category 4 includes portable or trailer-mounted devices such as arrow boards, changeable message signs, temporary traffic signals, and area lighting supports. Currently, there is no implementation date set for this category and it is exempt from the NCHRP 350 or MASH compliance requirement.

The Contractor shall provide a manufacturer's self-certification letter for each Category 1 device and an FHWA acceptance letter for each Category 2 and Category 3 device used on the contract. The letters shall state the device meets FHWA crashworthiness standards for its respective category and test level, and shall include a detailed drawing of the device. The set-up and use of certified/accepted devices shall be the same as that described in the letter.

At the time of manufacturing, the retroreflective prismatic sheeting used on channelizing devices shall meet or exceed the initial minimum coefficient of retroreflection as specified in the following table. Measurements shall be conducted according to ASTM E 810, without averaging. Sheeting used on cones, drums, and flexible delineators shall be reboundable as tested according to ASTM D 4956. Prestriped sheeting for rigid substrates on barricades shall be white and orange. The sheeting shall be uniform in color and devoid of streaks throughout the length of each roll. The color shall conform to the latest appropriate standard color tolerance chart issued by the U.S. Department of Transportation, Federal Highway Administration, and to the daytime and nighttime color requirements of ASTM D 4956.

Initial Minimum Coefficient of Retroreflection candelas/foot candle/sq ft (candelas/lux/sq m) of material				
Observation Angle (deg.)	Entrance Angle (deg.)	White	Orange	Fluorescent Orange
0.2	-4	365	160	150
0.2	+30	175	80	70
0.5	-4	245	100	95
0.5	+30	100	50	40

Only the name and telephone number of the agency, Contractor, or supplier may be shown on the non-retroreflective surface of devices. The letters and numbers shall be a non-retroreflective color and a maximum of 2 in. (50 mm) in height.

Devices shall also be constructed as shown on the plans and according to the following.

- (a) Lights. Lights shall meet the requirements of the Institute of Transportation Engineers Standard for Flashing and Steady-Burn Barricade Warning Lights. Lights are classified as follows.

Type A - Low intensity flashing
 Type B - High intensity flashing
 Type C - Steady burning

Lights shall consist of a metal or plastic case, solid state electrical circuit, and head. Lights shall be maintained so as to be visible on a clear night from a distance of 3000 ft (900 m). Type B lights, when required for daylight operations, shall be maintained so as to be visible on a sunny day from a distance of 1000 ft (300 m) when viewed without the sun directly on or behind the light.

- (1) Internal Power (Batteries). The batteries shall be provided by the Contractor but shall not be installed until the light is ready to be used. The light shall be constructed so when the batteries are installed, the terminals are on top of the battery. The batteries shall be contained within the case. The battery terminals shall be either plug or spring type. All electrical connections shall be of non-corrosive material.
 - (2) External Power. When external power is supplied, all power connections shall be hermetically sealed. The method of installing these lights shall be approved by the Engineer. There shall be an isolated fuse for each light. The fuse shall be located near the pavement edge between the light and the power source and shall be installed so that if one light is damaged, causing a short circuit, all lights will not be extinguished. In all cases, an additional emergency power supply shall be present for operation in the event of power failure. A portable generator may be used as a primary or secondary power source.
 - (3) Case. The case for the battery shall be constructed of aluminum, galvanized steel, or plastic of an orange, white, or metallic color. The case shall have a vandal-proof fastener on either or on both the side and back, suitable for mounting on barricades or signs. The case shall be weatherproof.
 - (4) Photoelectric Cell. All Type A and C lights shall be equipped with a switching circuit activated by a photoelectric cell. Type B lights may also be equipped with a photoelectric cell when 24-hour operation is not required in the contract.
 - (5) Testing and Marking. All lights shall be tested and certified as meeting these requirements by an independent laboratory. Two copies each of the full testing report and certification shall be provided to the Engineer. The report shall specify the lens manufacturer and part number, the circuit manufacturer and part number, the bulb number, and the minimum operating voltage at which the unit meets the intensity requirements of these Specifications. Each light shall be plainly and permanently marked with the type, manufacturer's name, and model number.
- (b) Cones. Cones shall be orange and constructed of a durable material able to withstand abuse by vehicular traffic. The minimum weights for the various cone heights shall be 4 lb for 18 in. (2 kg for 450 mm), 7 lb for 28 in. (3 kg for 700 mm), and 10 lb for 36 in. (5 kg for 900 mm) with a minimum of 60 percent of the total weight in the base. Reflectorized cones shall have two white bands.

- (c) Type I, II, and III Barricades, Vertical Barricades, and Vertical Panels. Barricades and vertical panels shall have alternating white and orange stripes sloping downward at 45 degrees toward the side on which traffic will pass. Barricade stripes shall be 6 in. (150 mm) in width on barricades rails 36 in. (900 mm) or greater in length and 4 in. (100 mm) in width on barricades barricade rails less than 36 in. (900 mm) in length. Type I and Type II Barricades shall be striped on both sides. Type III Barricades shall be striped on both sides where traffic approaches from either direction. Vertical panels placed on the outside of curves shall be striped on both sides. The predominant color for other barricade components shall be white, orange, or silver.

The face of the barricade rails may be sloping or vertical. Nominal lumber dimensions may be used to satisfy wooden barricade component dimensions.

- (d) Direction Indicator Barricades. The top panels shall be fluorescent orange and shall be 12 x 24 in. (300 x 600 mm). The black indicator arrow on the top panel shall be 21 in. (530 mm) long with a 9.5 in. (240 mm) wide arrow barb and 3.5 in. (90 mm) wide arrow shaft. The bottom panels shall be 8 x 24 in. (200 x 600 mm) with alternating white and orange stripes sloping downward at 45 degrees toward the side on which traffic will pass.
- (e) Drums. Drums shall be nonmetallic and shall have closed tops. Drums may be slightly conical in shape and may have one or more flat surfaces to minimize rolling when hit. Drums shall be weighted in a manner approved by the manufacturer so they are not moved by wind or traffic.

Drums shall have alternating white and fluorescent orange horizontal, circumferential stripes. There shall be at least two white and two fluorescent orange stripes on each drum. If non-reflective spaces are left between the white and fluorescent orange stripes, they shall be no more than 2 in. (50 mm) in width. All non-reflectorized portions of the drums shall be orange.

- (f) Flexible Delineators. Flexible delineators shall be designed to bend under repeated impacts and return to an upright position without damage to the impacting vehicle or the delineators. The delineators shall be readily removable from the bases to permit field replacement.

The delineators shall be orange in color having two white and two fluorescent orange bands.

- (g) Truck Mounted/Trailer Mounted Attenuators. The attenuator shall be either a NCHRP 350 or MASH approved unit for Test Level 3. Test Level 2 may be used as directed by the Engineer for normal posted speeds less than or equal to 45 mph.
- (h) Arrow Boards. Arrow boards shall be rectangular, of solid construction, and finished with non-reflective flat black. The boards shall be mounted as

shown on Standard 701901. Remote controls shall be provided with roof mounted arrow boards.

Arrow boards shall have the capability of the following mode selections: (1) left or right flashing shaft with arrow point; (2) flashing shaft with double arrow points; and (3) caution. The arrow point shall be composed of at least five lamps at an angle of 35 to 60 degrees measured from the horizontal shaft which shall be composed of at least three lamps. Shafts in the double arrow point mode shall be composed of at least two lamps for Type A units and three lamps for Type B and C units. The caution mode shall consist of four or more lamps, arranged in a pattern which will not indicate a direction. The lamps or lenses shall be recess mounted or alternately equipped with an upper hood of not less than 180 degrees, and the color emitted shall be yellow. The lamps shall be 12 V, water proof units, consisting of LED, Halogen, or sealed incandescent beams, spaced so as to substantially fill the board. Lamps shall be capable of a minimum of 50 percent dimming from their rated voltage. The flashing rate shall not be less than 25 nor more than 40 flashes per minute. Minimum lamp "on" time shall be 50 percent (no lamps shall remain illuminated during "off" time). All units shall have a permanently mounted voltmeter indicating the voltage available to the lamps. Trailer mounted units shall be equipped with a minimum of two indicator lamps on the near side of the arrow board.

Requirement	Arrow Board Type		
	A	B	C
Minimum Lamp Size	PAR 36	PAR 36	PAR 46
Minimum Number of Lamps	12	13	15
Minimum Legibility Distance: ^{1/}			
miles	1/2	3/4	1
meters	800	1200	1600

1/ Minimum legibility distances are those at which the arrow board can be comprehended by a driver on a sunny day or clear night.

The power to operate the arrow board shall be supplied from self-contained batteries, (with or without a solar panel generator), a vehicle's electrical system, a gasoline or diesel fueled generator, or an external power source. Where batteries are used as the primary power source, they shall be capable of providing sufficient voltage, between charging, to each of the lamps for a period of at least 72 continuous hours of operation, in any mode at full daylight intensity. Units utilizing gasoline or diesel fueled generators or an external power source shall be equipped with storage batteries wired so the unit will automatically switch to battery power in the event of failure of the primary power source. The batteries shall be capable of providing sufficient capacity to the lamps for at least three continuous hours of operation in any mode at full daylight intensity.

Where an external power source is used, the cable placement shall meet the approval of the Engineer, and all electrical codes applicable to the area shall be observed. When greater than 24 V is supplied externally, the service

cable shall be fused at a location sufficiently removed from the unit so as to leave no live wires exposed at or near the unit in the event of a vehicular collision.

Trailer-mounted units shall be equipped with a photoelectrically operated switch capable of varying the lamp voltage from 6 V for nighttime use to 12 V for daylight use. This switch shall not be capable of manual operation. Failure of this switch shall cause the lamps to operate in the dim mode (6 V) only. Roof-mounted units may be equipped with a manually operated voltage control switch.

- (i) Portable Changeable Message Signs. The sign(s) shall be trailer mounted. The message panel shall be at least 7 ft (2.1 m) above the pavement, present a level appearance, and be capable of displaying up to eight characters in each of three lines at a time. Character height shall be 18 in. (450 mm).

The message panel shall be of either a bulb matrix or disc matrix design controlled by an onboard computer capable of storing a minimum of 99 programmed messages for instant recall. The computer shall be capable of being programmed to accept messages created by the operator via an alpha-numeric keyboard and able to flash any six messages in sequence. The message panel shall also be capable of being controlled by a computer from a remote location via a cellular linkage.

The message panel shall be visible from 1300 ft (400 m) under both day and night conditions. The letters shall be legible from 750 ft (250 m).

The sign shall include automatic dimming for nighttime operation and a power supply capable of providing 24 hours of uninterrupted service.

- (j) Sign Trailers. Small, lightweight trailers may be used as temporary supports for construction and maintenance signs where post mounted signs are not required by the Highway Standards. The trailer, exclusive of signs, shall be no more than 300 lb (135 kg) and shall not be fabricated with heavier than 3 x 3 in. (75 x 75 mm) angles, 2 1/2 in. (63 mm) diameter pipes, or 3 x 2 in. (75 x 50 mm) rectangular tubing. The rim size of the wheels should not exceed 12 in. (300 mm). Automotive or truck rear axle assemblies with differential housings shall not be used. In the erected position, the tires may rest on the ground or be elevated with the bottom of the tires no greater than 6 in. (150 mm) above the ground. No weights other than sandbags shall be used and sandbags shall rest no higher than 12 in. (300 mm) above the ground. Wheel chocks other than sandbags shall not be used. The tongue may be pinned to the ground (or a paved area if approved by the Engineer) to reduce wind-induced rolling. Such a pin shall be designed to readily pull or break in the event of a vehicular impact. The method of pinning shall be approved by the Engineer.

Each end of the rear rail of the trailer shall be equipped with a 3 in. (75 mm) diameter or equivalent red reflector.

1106.03 Temporary Rumble Strips. The rumble strip shall be black in color and formed of high strength polycarbonate. The strip shall be of one-piece construction with two channels on the underside for flexibility and proper adhesive bondage. The channels shall be interconnected at four or more locations to permit the bonding material to flow from one channel to the other. There shall be at least six weep holes through one or both channels to the upper surface of the strip and at least four through the leading edge of the strip to prevent air voids between the strip and the bonding material.

The rumble strip shall be capable of supporting a load of 6000 lb (2700 kg). The load capacity shall be determined by placing a strip over the open end of a 1 in. (25 mm) high vertically-positioned hollow metal cylinder having an internal diameter of 3 in. (75 mm) and a wall thickness of 1/4 in. (6 mm). The load shall be applied slowly through a 1 in. (25 mm) diameter by 1 in. (25 mm) high metal rod centered on the top flat portion of the strip. No weep holes shall be in the compression area. Breakage or significant permanent deformation of the strip shall constitute failure. Other similar designs may be used with the approval of the Engineer.

APPENDIX A

METRIC UNITS OF MEASURE

Unit	Name	Symbol	Note
Length	meter	m	
Area	square meter	sq m	
	hectare	ha	(1 ha = 10,000 sq m)
Volume	cubic meter	cu m	
	liter	L	(1 L = 1000 cu cm)
Mass	gram	g	
	metric ton	metric ton	(1 metric ton = 1000 kg)
Density	kilogram / cubic meter	kg/cu m	
Force	Newton	N	(N = kg m/s ²)
Pressure, Stress	Pascal	Pa	(Pa = N/sq m)
Energy, Work	Joule	J	(J = N m)
Torque	Newton meter	N m	
Power	watt	W	(W = J/s)
Speed	meters / second	m/s	
	kilometers / hour	km/hr	
Temperature	degrees celcius	°C	

Prefixes

nano (n)	10 ⁻⁹	one billionth
micro (μ)	10 ⁻⁶	one millionth
milli (m)	10 ⁻³	one thousandth
centi (c)	10 ⁻²	one hundreth
deci (d)	10 ⁻¹	one tenth
deca (da)	10 ¹	ten
hecto (h)	10 ²	one hundred
kilo (k)	10 ³	one thousand
Mega (M)	10 ⁶	one million
Giga (G)	10 ⁹	one billion

APPENDIX B

ENGLISH TO METRIC CONVERSIONS

Unit	English	x	Conversion Factor	= Metric
Length	in.		25.4	mm
	ft		0.3048	m
	mile		1.6093	km
Area	sq in.		645.2	sq mm
	sq ft		0.0929	sq m
	sq yd		0.8361	sq m
	acre		0.4047	ha
Volume	cu in.		16387.1	cu mm
	cu yd		0.764555	cu m
	gallon		3.7854	L
Mass	ounces		28.3495	g
	lb		0.45359	kg
	kip (1000 lb)		0.45359	metric ton
	ton		0.9072	metric ton
Mass/area	ounces/sq yd		0.0339057	kg/sq m
	lb/sq ft		4.8824	kg/ sq m
	lb/sq yd		0.5425	kg/ sq m
	lb/acre		1.1208	kg/ha
	ton/acre		2.2417	metric ton/ha
Density	lb/cu ft		16.01894	kg/cu m
	lb/cu yd		0.5933	kg/ cu m
Force	pound		4.44822	N
	kip		4.44822	kN
Pressure, Stress	lb/sq ft		47.8803	Pa
	kip/sq ft		47.8803	kPa
	psi		6894.76	Pa
	ksi		6894.76	kPa
Energy, Work	foot pound		1.35582	J
Torque	foot pound		1.35582	N m
Power	hp		745.7	W
Speed	mph		1.6093	km/hr
Temperature	$(^{\circ}\text{F} - 32)/1.8 = ^{\circ}\text{C}$			

APPENDIX C

ABBREVIATIONS

The following is a list of unit abbreviations used throughout this book.

Unit - English (metric)	Abbreviation
Length	
thousandths of an inch (micrometer)	mils (μ m)
inch (millimeter)	in. (mm)
foot (meter)	ft (m)
mile (kilometer)	mile (km)
Area	
square foot (square meter)	sq ft (sq m)
square yard (square meter)	sq yd (sq m)
acre (hectare)	acre (ha)
Volume	
gallon (liter)	gal (L)
cubic yard (cubic meter)	cu yd (cu m)
Mass	
ounce (gram)	oz (g)
pound (kilogram)	lb (kg)
ton (metric ton)	ton (metric ton)
Force	
pound force (Newton)	lb (N)
pound force (kiloNewton)	lb (kN)
Pressure, Stress	
pounds per square inch (kiloPascal)	psi (kPa)
Energy, Work	
foot pound (Joule)	ft lb (J)
Torque	
foot pound (Newton meter)	ft lb (N m)
foot pound (kiloNewton meter)	ft lb (kN m)
Speed	
feet per minute (meter per minute)	ft/min (m/min)
miles per hour (kilometer per hour)	mph (km/hr)
Temperature	
degrees Fahrenheit (degrees Celsius)	°F (°C)
Electrical	
millivolt	mV
volt	V
kilovolt	kV
kilovoltampere	kVA
millampere	mA
ampere	A
hertz	Hz
watt	W
kilowatt	kW
ohm	ohm
color temperature, Kelvin	K

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