TENNESSEE DEPARTMENT OF TRANSPORTATION



STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION

January 1, 2015

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TENNESSEE DEPARTMENT OF TRANSPORTATION

The mission of the Tennessee Department of Transportation is to serve the public by providing the best multimodal transportation system in the nation.

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SECTION 101 – DEFINITIONS AND TERMS

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101.01 General

These Standard Specifications for Road and Bridge Construction apply to the bidder, before the award of the Contract, and to the Contractor after award. The sentences that direct the Contractor to perform work are written in the active voice/imperative mood. These directions to the Contractor are written as commands. For example, a requirement to provide cold weather protection could be expressed as:

> **Passive Voice / Indicative Mood:** Cold weather protection for concrete shall be provided by the Contractor.
>
> **Active Voice / Indicative Mood:** The Contractor shall provide cold weather protection for concrete.
>
> **Active Voice / Imperative Mood:** Provide cold-weather protection for concrete.

As shown in the above examples, in the active voice/imperative mood, the subject "the bidder" or "the Contractor" is understood. In these Specifications, this implied subject is typically the Contractor, although in certain situations, the subject may also be a vendor, fabricator, or manufacturer engaged by the Contractor to supply material, products, or equipment for use on the Project.

Sentences defining the actions or responsibility of the Department or its representative are generally written in active voice/indicative mood. Sentences written in the active voice/indicative mood identify the party responsible for performing the action. For example, "The Engineer will determine the density of the compacted material."

The following words refer to actions of the Department or its representative: "directed," "required," "ordered," "approved," "rejected," "acceptable," and

"satisfactory." These and words with similar meaning shall be understood to convey the same intent as if followed by the words "by the Engineer" or "to the Engineer."

The titles or headings of the Sections and Subsections in these Specifications are intended for convenience of reference and shall not be considered as having any bearing on the interpretation of the Specifications.

101.02 Abbreviations

These Specifications and other Contract documents use the following abbreviations:

ANLA	American Nursery Landscaping Association
AAR	Association of American Railroads
ACI	American Concrete Association
AASHTO	American Association of State Highway and Transportation Officials
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
ASLA	American Society of Landscape Architects
ASTM	American Society for Testing and Materials
AWPA	American Wood Preservers Association
AWWA	American Water Works Association
AWS	American Welding Society
FHWA	Federal Highway Administration
FSS	Federal Specifications and Standards, General Services Administration
IEEE	Institute of Electrical and Electronic Engineers
IES	Illuminating Engineering Society
IMSA	International Municipal Signal Association
ITE	Institute of Traffic Engineers
ICEA	Insulated Cable Engineers Association
ISSA	International Slurry Surfacing Association
MUTCD	Manual on Uniform Traffic Control Devices
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NCHRP	National Cooperative Highway Research Program
OSHA	Occupational Safety and Health Administration
SAE	Society of Automotive Engineers
SPIB	Southern Pine Inspection Bureau
SSPC	Society for Protective Coatings
TCA	Tennessee Code Annotated

TDEC	Tennessee Department of Environment and Conservation
UL	Underwriters Laboratories, Inc.

101.03 Terms

Wherever, in these Specifications or elsewhere in the Contract, the following terms, or pronouns in place of them, are used, the intent and meaning shall be interpreted as follows:

Addendum. Written interpretation or modification of any of the Contract documents, which is delivered to prospective bidders prior to the opening of proposals.

Advertisement. The public announcement provided by the Notice to Contractors, as required by law, inviting proposals for the Work to be performed or materials to be furnished.

Amendment. A revision to the electronic bid file, which may include adjusting a quantity, or adding, deleting, or revising Contract item(s).

Award. The formal acceptance by the Department of a proposal.

Base Course. The layer or layers of specified or selected material of designed thickness placed on a subbase or a subgrade to support a surface course.

Bidder. A pre-qualified individual, partnership, firm, corporation, or joint venture acting directly or through a duly authorized representative to submit a proposal to perform the advertised Work.

Box Bridge. A box culvert type structure consisting of a single box or multiple boxes, with or without a bottom slab, having a length, measured along the centerline of the roadway, of more than 20 feet between the inside faces of the outside walls.

Bridge. A structure erected over a stream, watercourse, highway, railroad or opening, for carrying traffic, having a length, measured along the centerline of the roadway, of more than 20 feet between the faces of end supports.

Calendar Day. Every day shown on the calendar.

Change Directive. A Change Order issued by the Department, when the Contractor has filed a claim, that allows the Department to compensate the Contractor for completed additional work as determined to be fair and reasonable by the Department and that does not require the consent or signature of the Contractor or Surety.

Change Order. A written agreement entered into by and between the Department and the Contractor, with the written assent of the Surety, covering modifications or alterations beyond the scope of the original Contract, and establishing any necessary new Contract items, any other basis of payment, and any time adjustments for the work affected by the changes. This Agreement becomes a part of the Contract when properly executed and approved.

Commissioner. The Commissioner of the Department of Transportation of the State of Tennessee.

Completion Date. The calendar date by which the Contract shall be completed when such date is shown in the proposal instead of a stipulation of a number of working days, or the date of final acceptance of the Work.

Construction Change. A completed document, approved by the Engineer, covering changes in the Plans, Specifications or quantities, and additional items and the basis of payment that have been established by a previously executed Change Order.

Contract. The written agreement between the Department and the Contractor setting forth the obligations of the parties thereunder, including but not limited to, performance of the Work, which includes the furnishing of labor, equipment, and materials, and the basis of payment.

The Contract includes the Instructions to Bidders; the proposal; all conditions and terms of the Contract form; Contract Payment and Performance Bond; Letter of Credit where applicable; Specifications, Supplemental Specifications, Special Provisions, and Addenda; Standard Drawings and Contract Plans; the Work Order; and Construction Changes and Change Orders that are required to complete the construction of the Project in an acceptable manner including authorized time extensions thereof; all of which constitute one instrument.

Contract Payment and Performance Bond. The approved form of security, executed by the Contractor and its Surety or Sureties, guaranteeing

complete execution of the Contract and all Change Orders, and the payment of all legal debts pertaining to the performance of the Work.

Contract Time. The number of working days or calendar days allowed for completion of the Contract or an item(s) of work, or the number of calendar days between the time of starting as determined by the Work Order, and the Completion Date including all authorized time extensions.

Contractor. The individual, firm, partnership, limited liability company, corporation, joint venture, or other business entity contracting with the Department for performance of the Work.

Controlling Activity of Work. Any portion of the Work, a change in which would cause an adverse impact to the critical path schedule.

Critical Path. The sequence and duration of activities of work that control the duration of the Project.

Critical Path Method (CPM). A process for defining the time-frame required and relationship (logic ties) between critical and non-critical activities associated with construction projects and their completion dates.

Department. The Department of Transportation of the State of Tennessee.

Detour. A temporary rerouting of road users onto an existing highway in order to avoid a temporary traffic control zone.

Disadvantaged Business Enterprise (DBE). A for-profit small business concern that is at least 51% owned by one or more individuals who are both socially and economically disadvantaged or, in the case of a corporation, in which at least 51% of the stock is owned by one or more such individuals, and whose management and daily business operations are controlled by one or more of the socially and economically disadvantaged individuals who own it. Black Americans, Hispanic Americans, Native Americans, Asian-Pacific Americans, and Subcontinent Asian Americans, as defined in 49-CFR Section 26.5, women, and any additional groups whose members are designated as socially and economically disadvantaged by the U.S. Small Business Administration are rebuttably presumed to be socially and economically disadvantaged. Other individuals may also qualify as socially and economically disadvantaged on a case-by-case basis.

Engineer. The Chief Engineer of the Department of Transportation or a duly authorized assistant or representative.

Equipment. All machinery, apparatus, and tools necessary for the proper construction and acceptable completion of the Project, plus the necessary repair parts, tools, and supplies for upkeep and maintenance.

Extra Work. An item of work not provided for in the Contract as awarded but found essential to the satisfactory completion of the Contract within its intended scope.

Force Account. A method of payment for Extra Work when a Change Order is not arrived at between the Engineer and the Contractor.

Highway, Road, and Street. Each of these words is a general term denoting a public way for the purpose of vehicular travel including the entire area within the right-of-way.

Holidays. Holidays recognized by the State of Tennessee occur as follows:

New Year's Day	January 1
Martin Luther King Day	Third Monday in January
Presidents' Day	Third Monday in February
Good Friday	Friday before Easter
Memorial Day	Last Monday in May
Independence Day	July 4
Labor Day	First Monday in September
Columbus Day	Second Monday in October
Veterans Day	November 11
Thanksgiving Day	Fourth Thursday in November
Christmas Day	December 25

All days appointed by the Governor of this State, or by the President of The United States, as days of fasting or thanksgiving.

Plan notes precluding restrictions to traffic on holiday weekends, unless specifically noted otherwise, do not apply to weekends associated with Martin Luther King Day, Presidents' Day, Columbus Day and Veterans Day.

Inspector. The authorized representative of the Engineer assigned to make detailed inspections of materials and Contract performance.

Instructions to Bidders. Instructions included in the document entitled "Instructions to Bidders," which give information to the bidder with regard to preparing the Proposal Guaranty and the Letter of Credit where

applicable. It also covers submission or delivery of the Proposal to the Department.

Item (Contract Item, Pay Item, or Bid Item). A specifically described unit of work for which a price is provided in the Contract.

Laboratory. The official testing laboratories of the Department or such other laboratories as may be designated or approved by the Engineer, acting only within the scope of the duties assigned to them individually.

Letter of Credit. A contractual promise to honor drafts presented for funds upon compliance with the terms and conditions specified. The Department shall have the authority to approve the issuer and prescribe said terms and conditions.

Major and Minor Items. Major Items will be determined as follows:

1. Any original Contract item having a value of 15% or more of the original Contract amount, based on the original estimated quantity, shall be a Major Item.

2. The accumulation of the least number of individual items that total at least 40% of the original Contract amount also shall be Major Items. The items shall be totaled sequentially starting with the largest item (based on original prices and quantities).

Any items that do not meet (1) or (2) above are Minor Items.

Materials. Any substance specified to be furnished or proposed for use in the construction of the Project and its appurtenances.

Notice to Contractors. A notice to Contractors and other interested parties of proposed construction to be bid giving the date the bids are to be received and the location and general description of the Work to be performed.

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

Plans. The approved plans, profiles, cross-sections, standard roadway and structure drawings, working drawings and supplemental drawings, or exact

reproductions thereof, which show the location, character, dimensions, and details of the construction to be performed under the Contract.

Prequalification. The procedure established and administered by the Department by virtue of which prospective bidders are required to establish their responsibility and qualifications in advance of submission of Proposals.

Project. The specific improvement, together with all appurtenances, to be constructed under the Contract.

Proposal. The offer of a bidder, on the prescribed form, to perform the Work at the prices quoted.

Proposal Form. The approved form on which the Department requires that Proposals be prepared and submitted for the performance of the Work.

Proposal Guaranty. The security furnished with a Proposal to guarantee that the bidder will enter into a Contract if the bidder's Proposal is accepted and the Contract is awarded to it.

Qualified Products List (QPL). A listing of products that have been tested or analyzed by the Department and have been approved for use on the Department's road construction projects.

Right-of-Way. A general term denoting land, property, or interest therein, usually in a strip, acquired for or devoted to a highway and its appurtenant structures.

Roadbed. The graded portion of a highway prepared as a foundation for the pavement structure and shoulders.

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.

Roadside Development. Those items necessary to the complete highway that 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.

Roadway. The portion of a highway within limits of construction.

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

Special Provisions. Provisions inserted into a contract revising the Standard or Supplemental Specifications, and covering conditions unique to the individual project.

Specifications. A general term applied to all directions, provisions, and requirements pertaining to the performance of the Work.

Standard Specifications. The *Tennessee Department of Transportation Standard Specifications for Road and Bridge Construction* and its revisions effective on the Contract execution date.

State. The State of Tennessee.

Subcontractor. Any individual, firm, partnership, limited liability company, corporation, joint venture, or other business entity to whom the Contractor or any Subcontractor, regardless of tier, sublets any part of the Work under the Contract.

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

Substructure. 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, wingwalls and wing protection railings.

Superintendent. The Contractor's authorized representative in responsible charge of the Work.

Superstructure. The entire structure except the substructure.

Supplemental Specifications. Approved additions and revisions to the Standard Specifications.

Surety. A company authorized to guarantee a bidder's proposal and a contractor's performance and payment obligations under a contract, which is authorized to do business in the State of Tennessee and is listed on the

United States Department of the Treasury Financial Management Service list of approved bonding companies.

Work. The furnishing of all labor, materials, equipment, and incidentals necessary for the satisfactory completion of the Project, including the carrying out of all duties and obligations imposed by the Contract.

Working Day. A calendar day, exclusive of Saturdays, Sundays, and Holidays, which weather or other conditions not under the control of the Contractor will allow construction operations to proceed for at least 5 hours of the day with the normal working force engaged in performing the Work, which are normal to progress at the time, as determined by the Engineer.

Working Drawings. Stress sheets, shop drawings, erection plans, falsework plans, framework plans, cofferdam plans, bending diagrams for reinforcing steel, or any other supplementary plans or similar data that the Contractor is required to submit to the Engineer for approval.

Work Order. Written notice to the Contractor to proceed with the Work under the Contract, including, when applicable, the date of beginning of Contract Time.

SECTION 102 – BIDDING REQUIREMENTS AND CONDITIONS

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102.01 Prequalification Questionnaire and Competency of Bidders

Each prospective bidder and subcontractor must file a "Prequalification Questionnaire" and be prequalified by and in good standing with the Department according to Rules of the Tennessee Department of Transportation, Chapter 1680-5-3, Prequalification of Contractors. Good standing means that the bidder or subcontractor is currently pre-qualified and not subject to any temporary disqualification according to Chapter 1680-5-3, Prequalification of Contractors, and not subject to suspension, debarment, or voluntary exclusion according to Rules of the Tennessee Department of Transportation, Chapter 1680-5-1, Contractor Debarment and Suspension. Notify the Department if there is any subsequent change in the name, organization, or contact information provided.

The Department will determine prequalification status and reserves the right to refuse bid authorization or subcontractor approval based on the factors listed in Chapter 1680-5-3.07.

102.02 Contents of Proposal Forms

Upon request, the Department will furnish the bidder an electronic proposal form containing an "Instructions to Bidders" form, Supplemental Specifications, Special Provisions, and Proposal Guaranty form. The proposal form will state the location and description of the contemplated construction. The proposal form will state the time in which the Work must be completed, the amount of the Proposal Guaranty, and the date, time and place for the opening of proposals. The Plans and Specifications are as much a part of the proposal form as if they were bound therein. All of the documents contained therein are part of the proposal.

The prospective bidder will be required to pay the Department the sum stated in the Instructions to Bidders for each electronic proposal form. Plans will be available for the sum stated in the Notice to Contractors.

102.03 Interpretation of Quantities in Bid Schedule

The quantities appearing on the electronic bidding file are approximate only and are prepared for the comparison of bids and award of Contract. The Department does not guarantee or assume any responsibility that quantities shown on the Plans or given in the electronic bidding file will hold in the construction of the Project, and the Contractor shall not claim deception or misunderstanding because of variation in these quantities or variation from the location, character of the work, or any other conditions. The Department will pay the Contractor only for the actual quantities of work performed and accepted, and materials furnished in accordance with the Contract. The schedule of quantities of work to be done and materials to be furnished may be increased, decreased, or omitted as provided under **104.02**.

102.04 Examination of the Site, the Work, the Plans, the Permits, and the Specifications

The bidder assumes the responsibility to examine the site of the Work, including the surrounding terrain, borrow sites, and access facilities, and the Plans, Specifications, and all other documents making up the Proposal and Addenda. It is mutually agreed that submission of a proposal is considered prima facie evidence that the bidder has performed a reasonable site investigation and is familiar and satisfied with the character, quality, and quantity of work to be performed, materials to be furnished, the permits, and proposal requirements.

When requested and available, the Department will provide for the bidder's review one or more of the following:

1. Record drawings.

2. Information relative to subsurface exploration, borings, soundings, water levels, or profiles.

3. The results of other preliminary investigations.

A reasonable site investigation includes a review of these documents.

The Department makes no guarantees regarding the character or extent of utilities, water levels, soil, rock, or other subsurface conditions the bidder may encounter during the Work. The Department interpolates test data from completed borings in its reports and representations of subsurface conditions, and does not guarantee the accuracy of these interpolations, nor does the Department guarantee the accuracy of the test data except at the exact points where samples were taken. The Department requires bidders to make their own evaluation of subsurface conditions and to determine how these conditions may affect the methods and cost of construction. Material quality within sources naturally varies, so expect this.

Immediately notify the Department of any apparent error, omission, or ambiguity in any part of the proposal. The Department will review the apparent error, omission, or ambiguity, and will issue an addendum to all prospective bidders, as appropriate.

If the Department becomes aware of a change in the information provided at any time during the bidding process, it will provide reasonable written notice of the new information to the bidders or Contractor.

102.05 Preparation of Proposals

A document entitled "Instructions to Bidders" is included with the electronic proposal form. Electronically sign both the proposal form and the proposal guaranty form as directed in these instructions using the electronic bidding file furnished by the Department. Submit the completed electronic bidding file, inclusive of the proposal form as described in **102.02** and the bid prices described below, to the Department as directed in the applicable part of these instructions.

The electronic bidding file contains the contract bid items and associated estimated quantities. The following stipulations shall apply to electronic bidding:

1. Compare the bid quantities shown on the Plans to those contained on the electronic bidding file to ensure they are the same. Immediately notify the Department of any discrepancies.

2. For any revisions to the proposal regarding bid items or quantities, the Department will provide an amendment to the electronic bidding file indicating the revision date. Use the amended electronic bidding file in formulating the bid.

For proposals containing alternates, bid on only one alternate for each construction item. Enter prices for the intended alternate item(s) of construction and leave the undesired alternate item(s) of construction blank. The electronic bidding program allows for only one alternate to be bid. If prices are entered for more than one alternate, the electronic bidding program will not tabulate the total.

The electronic bidding program will perform all extensions of the estimated quantities and unit or lump sum prices, calculate the total bid, and allow the printing of a complete set of bid item sheets with appropriate subtotals and grand total bid price.

102.06 Delivery of Proposals

Submit each proposal via the Internet using the electronic bidding program. The Department will not consider or accept a proposal that has not been received by the time, date, and at the place set forth for the bid opening in the Instruction to Bidders.

102.07 Withdrawal of Proposal

A bidder may withdraw a proposal through the electronic bidding program prior to the hour of bid opening as indicated in the Instruction to Bidders.

102.08 Public Opening of Proposals

The Department will open proposals and will either read them publicly, or furnish and post bid totals on the date, time, and place indicated in the Instruction to Bidders. Bidders, authorized agents, and interested parties are invited to be present.

102.09 Rejection of Proposals

The Department will not reject proposals solely because their consideration is conditioned upon the elimination of other proposals submitted by the same bidder at the bid opening, provided that the Department reserves the right to make awards on combination bids or separate bids as it determines to be in its best interests. A bidder may tie the acceptance or rejection of two or more proposals on the condition that either all proposals are accepted or all are rejected, in which case the bids will be rejected unless each bid is the lowest responsive bid on each project.

The Department may reject a proposal if any of the unit prices contained therein are materially unbalanced, either excessive or below the Engineer's estimate. A materially unbalanced bid generates a reasonable doubt that award to the bidder submitting a mathematically unbalanced bid will result in the lowest ultimate cost to the Department. A mathematically unbalanced bid contains lump sum or unit bid items that do not reflect reasonable actual costs and a proportionate share of bidder's anticipated profit, overhead costs, and other indirect costs.

The Department may reject any proposals as non-responsive if:

1. Proposals fail to contain a unit price for each item listed.

2. Proposals are not prepared on the prescribed forms.

3. Proposals show any unauthorized omissions, conditions, alterations of form, additions, or irregularities of any kind.

4. Proposals show unauthorized alternate bids. In the case of authorized alternate items, a unit price on only one of the alternates will be required, unless otherwise specified in the Contract.

5. Proposals are not electronically signed by an authorized representative of the bidder. The electronic signature on the electronic bidding file serves as signatures for the proposal form, proposal certification form and the proposal bond form, if applicable.

6. When electing to submit a Proposal Guaranty, the bidder fails to submit a signed Proposal Guaranty in the proper character and amount indicated on the proposal form.

7. The Proposal Guaranty is not properly signed by the Agent or Attorney-in-Fact representing a Surety accompanied by a dated and valid Power of Attorney for the Attorney-in-Fact. The date on the Power of Attorney must match the date on the Proposal Guaranty.

8. A bidder is not prequalified and in good standing on the date of letting in accordance with **102.01** and Chapter 1680-5-3, Prequalification of Contractors.

9. There are reasonable grounds for believing that any bidder is interested in more than one proposal on the same project, or that there has been collusion among the bidders. Evidence of collusion will cause a rejection of all proposals in which the bidders involved are interested.

10. The apparent low bidder fails to complete and submit the Department form "Certification Regarding Subcontractor Bid Quotes" (Bidders List) electronically before the close of business (4:30PM Central Time) within seven (7) calendar days after the date on which bids are required to be submitted.

11. A bidder fails to deposit bid escrow documentation, if required.

12. A bidder fails to acknowledge addenda.

13. A bidder does not obtain or have a license with the Tennessee Department of Commerce and Insurance (TDCI), Board for Licensing Contractors (BLC) within twenty-one (21) days in accordance with **102.11**.

102.10 Proposal Guaranty

With each electronic bid, submit an electronic Proposal Guaranty in accordance with the Instructions to Bidders. Ensure that the Proposal Guaranty form is complete and furnished by a Surety as defined in **101.03**, and that the Proposal Guaranty has a Power of Attorney executed by the Surety. The proposal and the Proposal Guaranty shall be valid and binding for sixty (60) days subsequent to the date of opening bids.

102.11 Licensing of Bidders

All prime Contractors, except mowing and litter removal Contractors, must be licensed with the Tennessee Department of Commerce and Insurance, Board for Licensing Contractors (BLC). The Contractor must be licensed in the general classification (e.g. Heavy Construction (HC); Highway, Railroad, Airport Construction (HRA); Specialty (S); Municipal and Utility Construction (MU); or Electrical Contracting (CE)) for the type of work in the Project that they will perform. Contractors for mowing or litter removal type contracts must be registered with the Secretary of State (i.e., have a valid Certificate of Existence/Authorization), if applicable, before a Contract will be awarded.

A proposal submitted by a bidder will be considered for award for 21 days after the proposals are opened. If the bidder does not have a license with the BLC, on or before twenty-one (21) days after proposals are opened, the bidder will be considered non-responsive and its proposal will be rejected as irregular. The next lowest responsible bidder will then be considered for award. If the next lowest responsible bidder does not have a license on or before the twenty-one (21) days after the proposals are opened, they also will be considered non-responsive, and the subsequent bidder will then be considered.

Bidders that are domestic or foreign corporations, limited liability companies, limited partnerships, or limited liability partnerships, must be in good standing with the Secretary of State (i.e., have a valid Certificate of Existence/Authorization). If a bidder is not in good standing with the Secretary of State on or before twenty-one (21) days after proposals are opened, the bidder will be considered non-responsive and its proposal will be rejected.

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103.01 Consideration of Proposals

The electronic bid is the only official bid.

After the proposals are opened, the Department will compare proposals based on the summation of the products of the unit bid prices and the approximate quantities. The results of such comparisons are public information.

The Department reserves the right to reject any or all proposals, to waive technicalities, or to advertise for new proposals in the best interests of the Department.

103.02 Return of Proposal Guaranties

As soon as the proposal prices have been compared, the Department will return Proposal Guaranties accompanying the proposals not likely in its judgment to be involved in making the award. The Department will return all other Proposal Guaranties to the remaining bidders after satisfactory Contract and Contract Payment and Performance Bond or Letter of Credit, where applicable, have been executed and accepted.

103.03 Material Guaranty

Before Contract award, the Department may require the bidder to furnish a complete statement of the origin, composition, or manufacture of any or all materials proposed to be used in the construction of the Project, together with samples. The samples may be subjected to tests, provided for in these Specifications, to determine their quality and fitness for the construction.

103.04 Award of Contract

The Department will either award a contract to the lowest responsive bidder according to TCA §54-5-116 within thirty (30) days after the formal opening of proposals, or it will reject all proposals received on the Project.

If a bidder submits qualified bids where the bidder ties acceptance or rejection of two or more proposals on the condition that either all proposals are accepted or all are rejected, the bids will be rejected unless each bid is the lowest responsive bid on each project. If the combination bid is rejected, the Department may award the Contract to the second lowest responsive bidder.

The Department will only award a contract to a contractor that is licensed in accordance with **102.11**.

103.05 Cancellation of Award

The Department reserves the right to cancel the award of any contract, at any time prior to execution of the Contract by all parties without liability.

103.06 Execution of Contract and Contract Payment and Performance Bond

The bidder to whom the Contract is awarded shall sign and return the Contract to the Department along with the fully executed Contract Payment and Performance Bond or Letter of Credit, where applicable, in a sum equal to 100% of the amount of the Contract, within ten (10) days after the receipt of notice of award and receipt of contract forms from the Department.

A contract is not considered binding until it has been executed by all parties.

103.07 Failure to Execute Contract

If the bidder fails to execute the Contract and to file an acceptable Contract Payment and Performance Bond or Letter of Credit, where applicable, within ten (10) days after notice of award, the Department may cancel the award and retain the Proposal Guaranty, not as a penalty, but as liquidated damages. The Department may then award the Contract to the next lowest responsive bidder, re-advertise the Work, or take other action, as the Department may decide.

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104.01 Intent of Contract

It is the intent of the Contract to provide for the construction and completion of the Work in accordance with the Plans, Specifications, and all other Contract documents.

104.02 Changes in Plans or in Character of Construction

The Department reserves the right to make changes to the Work at any time including alterations in the Plans, increases or decreases in quantities, Extra Work, or eliminated items. Such changes shall not invalidate the Contract nor release the Surety. The Contractor agrees to perform the Work as altered, the same as if it had been a part of the original Contract.

Under no circumstances shall changes in the Plans or in the character of the Work involve work beyond the termini of the proposed construction except as may be necessary to satisfactorily complete the Project.

A. 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, promptly notify the Engineer in writing of the specific differing conditions in accordance with **104.03** before the site is disturbed and before the affected work is performed. Upon written notification, the Engineer will investigate the conditions, and if it is determined that 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, the Engineer will make an appropriate Contract adjustment, excluding loss of anticipated profits, in accordance with **108.07** and **109.04** and the Contract modified in writing accordingly.

The Department will not allow Contract adjustments under this Subsection for any portion of the Work unaffected by differing site conditions.

B. Suspensions of Work Ordered By the Engineer

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 (not originally anticipated, customary, or inherent to the construction industry) and the Contractor believes that additional compensation, contract time, or both compensation and time is due as a result of such suspension or delay, the Contractor shall notify the Engineer in writing and provide information in accordance with **104.03**. If the Engineer agrees that the cost or time required for the performance of any work under the Contract has increased as a result of such suspension and the suspension was caused by conditions beyond the control of and not the fault of the Contractor, its suppliers, or subcontractors at any tier, and not caused by weather, the Engineer will make appropriate Contract adjustments in accordance with **108.06** and **109.04**.

No Contract adjustment will be allowed under this Subsection 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.

C. Significant Changes in the Character of Work

The term “significant change” will apply only to the following circumstances:

1. 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

2. When a Major Item is increased or decreased by more than 25% of the original Contract quantity. Adjustments shall apply only to that portion in excess of 125% of original Contract quantity, or in case of a decrease, to the actual quantity performed.

If the Contractor believes there to be a significant change in the character of work, notify the Engineer in writing and provide information in accordance with **104.03**. If the alterations or changes in quantities significantly change the character of Work, the Department will make appropriate Contract adjustments, excluding loss of anticipated profits, in accordance with **108.06** and **109.04** as applicable.

D. Extra Work

When necessary or desirable to complete the Contract, the Engineer may direct the Contractor to perform work not provided for in the Contract, but essential to the satisfactory completion of the Work within the intended scope. The Department will pay for Extra Work in accordance with **109.04** and will determine additional time in accordance with **108.07**.

E. Eliminated Items

The Department may partially or completely eliminate Contract items and will reimburse the Contractor only for those costs in accordance with **109.05** incurred before the Contractor's receipt of written notification of the elimination.

104.03 Contract Change Notification

It is the responsibility of the Contractor to provide reasonable written notice when conditions are believed to require a change to the Contract. The Department will only consider requests for changes to the Contract when the Contractor meets the notification procedures specified in this Subsection.

A. Written Notification by Contractor

Provide immediate written notification to the Engineer upon discovering a condition that may require a change to the Contract. Provide the following information, in writing, within fourteen (14) calendar days of notification:

1. A description of the condition, including the time and date first identified, and the location, if appropriate.

2. An explanation of why the condition represents a change to the Contract, with references made to **104.02** and other pertinent portions of the Contract.

3. A statement of all changes considered necessary to the Contract price(s), delivery schedule(s), phasing, and time. Because of its preliminary nature, the Department recognizes that this information may rely on estimates.

After notifying the Engineer, continue to perform the Work under the Contract including the work subject to the condition, and maintain records of actual labor, equipment, and materials used in accordance with **109.04**.

B. Written Acknowledgement by Engineer

The Engineer will provide written acknowledgement of the Contractor's written notice within five (5) calendar days.

C. Written Response by Engineer

The Engineer will provide a written response within fourteen (14) calendar days of receiving the Contractors written notice that includes one of the following:

1. A confirmation that a change is necessary in accordance with **104.02**, and direction on how the Work will proceed.

2. A denial of the request for a change, which will include references to the Contract as to why the condition does not represent a change.

3. A request for additional information stating the specific information needed and the date by which it must be received. The Department will respond to the additional information provided within fourteen (14) calendar days.

When a change is necessary, the Engineer will make appropriate adjustments to the Contract price and time, if warranted, in accordance with **108.07**, **109.04**, **109.05.A**, and **109.06**. If the Contractor disagrees with the Engineer's decision or does not agree with the Contract adjustments, the Contractor may pursue the issue as a claim in accordance with **105.16**.

104.04 Maintenance of Traffic

Unless otherwise provided, keep all roadways and access for vehicular travel open to all traffic while under construction. Maintain all traffic control features over the section of road under construction in accordance with the MUTCD and with Section **712** of these Specifications. Where indicated on the Plans, bypass the traffic over approved detour routes. Keep the portions of the Project being used by the public, whether it is through or local traffic, in such condition that traffic is adequately and safely accommodated. The Department will change the traffic control plan when necessary to maintain safety or reduce traffic congestion. Construct and maintain in a safe condition temporary approaches or crossings and intersections with trails, roads, streets, businesses, parking lots, railroads, residences, garages and farms. Provide for mowing or other vegetation removal to ensure safe sight distance at intersections. Do not use median crossovers on controlled access routes for construction traffic, except in areas, approved by the Engineer, where traffic control devices allow for the safe movement of construction traffic.

The Department will pay for materials used at the direction of the Engineer to construct and maintain approaches, crossings, intersections, and other features at Contract unit prices unless the Contractor is responsible for the damage. Maintenance of traffic control features, mowing, and pothole patching (cold mix) are incidental to the work and the responsibility of the Contractor.

Except in emergencies, lane closures are not permitted on any State routes without the explicit consent of the Engineer. On projects where work is required in traffic lane(s) or where a lane closure is necessary for public safety, submit a request to the Department at least seven (7) working days prior to the date of the anticipated lane closure(s). If all lanes in one or both

directions on an interstate route are to be closed for any length of time, submit a request at least fourteen (14) calendar days before the anticipated event. All requests for lane closure(s) must list the exact location, the time that the closure will begin, the estimated duration of the closure, and reasons for the proposed lane closure. Unless otherwise stated in the Contract, the Department will assess liquidated damages of $1000 per hour per lane for roadways greater than 25,000 ADT and $500 per hour per lane for areas less than 25,000 ADT for any closure that exceeds the approved lane closure duration.

Do not close lanes or restrict traffic on the following days without the Engineer's written consent:

- Easter: After 6:00 pm on the Thursday preceding Good Friday through and including Easter Sunday
- Memorial Day: After 12:00 noon on the preceding Friday through Memorial Day
- Independence Day: The observed holiday and preceding day plus weekend days either preceding or following these two days
- Labor Day: After 12:00 noon on the preceding Friday through Labor Day
- Thanksgiving: After 12:00 noon on Wednesday before Thanksgiving through Sunday following Thanksgiving
- Christmas/New Year's Day: December 24 through January 1 and any preceding and/or following days that fall on a weekend

The Engineer will allow off-road work on the above days only to the extent that no impact will be caused to the highway users. The Department will assess a $5,000 penalty against subsequent Contractor payment estimates for each violation of this rule.

The Department will maintain all public highways, roads and streets that are designated on the Plans as detours, but not designated as "Haul Roads".

During any written suspension of Work, make passable and open to traffic portions of the Project and temporary roadways as may be directed by the Engineer for the temporary accommodation of traffic during the anticipated

period of suspension. Maintain temporary routes or lines of travel until the Engineer orders by written notification the resumption of construction operations. When work is resumed, replace or renew any work or materials lost or damaged because of such temporary use of the Project. Remove, to the extent directed by the Engineer, any work or materials used in the temporary maintenance, and complete the Project in every respect as though its prosecution had been continuous. The Department will pay for materials used for maintenance and restoration of the Work when directed by the Engineer, at Contract unit prices.

104.05 Maintenance During Construction

Maintain the Work during construction and until the Project, or section(s) thereof, is accepted in accordance with **105.13**.

Continuously maintain the Work with adequate equipment and forces so that the roadway or structures are kept in satisfactory condition at all times. When placing a new course upon a previously constructed course or subgrade, maintain the previous course or subgrade during all construction operations. Provide litter pickup, mowing, and vegetation removal throughout the life of the Project in accordance with **806**.

The costs for maintenance work during construction and before the Project is accepted will not be paid separately, but is incidental to the cost of the Work.

104.06 Movement of Heavy Equipment

The Contractor's attention is called to the application of local, State, and Federal regulations governing construction work. Various municipalities as well as the Department require a permit for moving heavy equipment. The Contractor is responsible for applying for and procuring such permits, when required, from the appropriate municipal officials and the Department of Transportation.

104.07 Operation of Earthmoving and Hauling Equipment

When operating earthmoving equipment or hauling equipment on or across city streets or public roads, obtain specific written permission for such operations from the appropriate officials and deliver a copy of such permission to the Engineer prior to commencement of such operations. Keep the affected streets or public roads reasonably free of loose earth and

debris during movement of equipment, and thoroughly clean the affected streets or roads at the end of each day they have been used.

Provide flagging services in accordance with **712.04** as directed by the Engineer at locations where earthmoving equipment crosses or enters a city street or public road.

Repair damage to city streets, public roads, and adjacent property as directed by the Engineer at no additional cost to the Department.

The cost of cleaning city streets or public roads, of any required flagging of city streets or public roads, and of any repairs to city streets, public roads, or adjacent property will not be paid separately, but is incidental to the cost of the Work.

104.08 Dust Control

Take all available precautions to control dust. If the Engineer judges dust to be a problem, control the dust by sprinkling, by applying calcium chloride, or by other methods as directed. Payment for dust control is incidental to applicable Contract items and will be full compensation for the work required to control dust. No additional compensation will be allowed for delays caused by necessary dust control operations.

104.09 Rights in and Use of Materials Found on the Work

Use stone, gravel, sand, or other material determined suitable by the Engineer, as may be found in the excavation for the Project. The Department will pay for the excavated materials at the corresponding bid price for the excavated material. Replace excavated material used for embankments, backfills, or approaches with other material acceptable to the Engineer at no additional cost to the Department. No charge for the materials so used will be made against the Contractor. Do not excavate or remove any material from within the right-of-way that is not within the grading limits, as indicated by the slope and grade lines, without the Engineer's written authorization.

The material from any existing structures, water lines, sewers, utilities, and similar features, which are required to be removed in the course of construction, shall become the property of the Contractor to use or dispose of in accordance with the applicable statutes or regulations governing such materials, unless otherwise shown on the Plans.

Commercial grade coal found in the excavation for the Project shall become the property of the Contractor and shall be removed from the Project or shall be disposed of in a suitable waste site as approved by the Engineer. Replace all coal found in the excavation with an equivalent amount of acceptable material at no cost to the Department when needed for construction of the Project.

104.10 Final Cleanup

Before final acceptance of the Work, clean the entire right-of-way, all material pits, all waste areas, all areas and access roads used by the Contractor, all streams affected by the Work, and all ground occupied by the Contractor, in connection with the Work. Remove all forms, false work and temporary structures, temporary erosion control measures, excess materials, equipment, rubbish, and waste. Leave all parts of the Work in a neat and presentable condition. Stabilize the entire right-of-way, all material pits, all waste areas, all areas and access roads used by the Contractor according to the TN NPDES Construction General Permit criteria or the agreed upon Reclamation Plan. Mow the right-of-way as required for final cleanup. If the Project was graded under a previous contract, perform final cleanup within the construction limits of the current work being performed and other areas disturbed or otherwise requiring cleanup due to the Contractor's operations. Do not deposit rubbish, waste or debris on or in sight of the right-of-way. Replace and repair all damage to private and public property in accordance with **107.14**.

104.11 Value Engineering Change Proposal (VECP)

The Contractor may request a modification to the Plans, the Specifications, or other Contract requirements based on a Value Engineering Change Proposal (VECP) submitted to the Department specifying a cost reduction change. This will not apply to a proposal unless it is identified as a VECP at the time of its submittal.

VECP are those proposals that would require a change in the Contract and would result in an immediate net savings to the Department without impairing the essential functions and characteristics of the Project, including but not limited to, any warranties, service life, reliability, economy of operation, and maintenance and safety features. The Department will not normally consider VECPs that propose a total savings of less than $25,000 unless there are other non-monetary savings to be realized.

The Contractor may submit for review a "VECP Concept" provided that it contains enough information to clearly define the work involved and the benefits to be realized. Provide all applicable design criteria that will be used in the VECP design. Written notification by the Department that the review has been completed and that the VECP Concept appears to be favorable merely indicates that the engineering and plan development may continue for submittal of the VECP and is not authorization to begin any construction work contemplated by the VECP. Should the final design not reflect the expected benefits, the Department may reject the VECP Concept and the VECP without recourse by the Contractor.

Submit the following information to the Engineer as a minimum, with each VECP, allowing adequate time for Department analysis and processing without interference with project schedules:

1. A description of the difference between the existing Contract requirements and the proposed change, and the comparative advantages and disadvantages of each including cost and time savings.

2. An itemized list of the Contract changes required if the VECP is accepted, and any recommendation as to how to make each such change.

3. A separate detailed cost estimate for:

    a. the affected portions of the existing Contract requirements, and
    b. the VECP.

4. A prediction of the effects the proposed change will have on other Department costs, such as costs of maintenance and operation.

5. A statement of the time by which a Change Order must be issued in order to obtain the proposed cost reduction for the Project, noting the effect on the Contract completion time or delivery schedule.

6. The date(s) of known previous or concurrent submissions of the same VECP and previous actions by the Department.

7. The Contract items affected by the proposed change, including the associated quantity changes.

The Department may determine at any point during the evaluation process that the VECP is not cost effective and reject the VECP without recourse by the Contractor.

While a VECP is being considered by the Department, continue to perform the Work in accordance with the requirements of the Contract. The Department shall not be liable for failure to accept or act upon any VECP within the proposed time for review and processing or for any delays to the Work due to the submitted VECP. The Department will be the sole judge of the acceptance or rejection of a VECP, either wholly or in part. If an agreement has not been reached by the date that the Contractor's VECP specifies that a decision should be made, or such other date as the Contractor may have specified in writing, the VECP shall be deemed rejected.

The Contractor shall have no claim against the Department for additional costs or delays resulting from the rejection of a VECP, including but not limited to, VECP Concept or VECP acceptance, engineering and development costs, loss of anticipated profits, and increased material or labor costs.

The Department will not normally consider a VECP that would require any changes in pavement design, right-of-way, relocation of bridges, or any changes that would require modification of the approved environmental documents for the project. Right-of-way cannot be purchased as part of a VECP. The Department will not accept a VECP that is similar to a change in the Plans or Specifications under consideration by the Department for the Project at the time the VECP is submitted; nor will the Department accept a VECP based upon, or similar to, Standard Specifications, general use Special Provisions or Standard Drawings adopted by the Department after the advertisement for the Contract. The Department reserves the right to make such changes without compensation to the Contractor in accordance with **104.02**.

The Department will determine the estimated net savings from the adoption of all or any part of the VECP. In determining the estimated net savings, the Department may disregard the Contract bid prices if, in its judgment, such prices do not represent a fair measure of the value of the work to be performed or to be deleted.

If the Department accepts the VECP, the Contractor grants to the Department all rights to adoption of the VECP for general use on other contracts without obligation or compensation of any kind.

Acceptance of a VECP will be by Change Order incorporating the changes necessary to allow the VECP, or any part of it, to be put into effect. The Change Order will also set forth the estimated net savings to the Department and further provide that the Contractor be paid 50% of the actual net savings.

The cost to develop, design, and implement the VECP, including redesign by a Tennessee-licensed engineer, preparation of new reproducible plans, and any other information requested by the Department to facilitate its review, is incidental to the Contractor and will not be reimbursed as part of the VECP net savings payment. The cost to the Department to review the VECP is incidental to the Department and will not affect the VECP payment.

The Department will determine the actual net savings when the work in the VECP and Change Order is completed. If upon completion of the work proposed in the VECP, the Department determines that the Change Order did not adequately address a change in quantities for other pay items that were either increased or decreased substantially as a result of the VECP, those additional costs or savings will be included in the actual net savings determination. The Department will make a single payment to the Contractor representing 50% of the actual net savings once all items are considered.

If the completed VECP results in an increase in cost such that there is no net savings, the Department will reimburse those costs above the original Contract amount reflected in the VECP and Change Order at a rate of 50%.

The preparation of the VECP, its acceptance and performance of the work shall not extend the Contract completion time unless the Change Order provides for an extension.

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105.01 Authority of the Engineer

The Engineer will have full professional and executive charge of supervision of the Work, and will decide all questions that may arise concerning the following:

1. The quality and acceptability of materials furnished and work performed,
2. The rate of progress of the Work,
3. The quantity of work that has been performed at any given time,
4. All questions that may arise as to the interpretation of the Plans and Specifications,
5. The acceptable fulfillment of the Contract, and

6. Contractor compensation.

In all of these matters, the decision of the Engineer will be final and binding; decisions of a purely contractual or legal nature will be subject to appeal in writing by the Contractor to the Commissioner.

The Engineer will have the authority to suspend the Work and withhold payment wholly or in part, if the Contractor furnishes materials or uses workmanship that are not fully acceptable, or fails to comply fully with any orders or with any provisions of the Contract. The Engineer also may suspend the Work, wholly or in part, for such periods as it deems necessary, due to unsuitable weather, conditions considered unsuitable for the prosecution of the Work, or as deemed to be in the public interest.

105.02 Plans and Working Drawings

All contractors and subcontractors directly engaged in the erection or removal of falsework, temporary structures, structural steel, precast prestressed or mild steel reinforced concrete bridge beams or girders over active highway traffic lanes, on any route, railroad or any stream deemed navigable to commercial or pleasure water craft, shall submit an erection plan prepared and stamped by a Professional Engineer licensed in the State of Tennessee. See also **602.41**, **602.42**, and **604.06**.

The Contract Plans, generally, will show sufficient details and dimensions to define the Work. When additional details and dimensions are needed, prepare working drawings and submit them to the Engineer for approval. Submission of working drawings will not serve to change the intent of the Contract documents. The Contractor may instruct the fabricator to submit shop or working drawings directly to the Department. The Department will construe the fabricator to be an agent of the Contractor and will consider any changes to the Contract Plans submitted by the fabricator as made by the Contractor. The Contractor shall bear all costs for changes other than those required by the Department. Unless otherwise noted on the Plans or Specifications, shop drawings for all types of structures shall be submitted by, or on behalf of the Contractor, directly to the Division of Structures, for processing and distribution by the checking agency. Proof of appropriate fabricator certification for the type of structure to be fabricated shall be submitted along with the shop drawings.

Submit shop drawings for the following items:

Structural steel, metal bridge rails, bearing devices (shop drawings not required for plain elastomeric bearing pads), bridge deck drains (shop drawings not required if fabricated according to applicable Standard Drawing), navigation lighting support brackets, precast prestressed concrete beams, precast prestressed concrete deck panels, precast reinforced concrete beams, precast concrete box and three-sided culverts (not required if built in accordance with Department standards or published ASTM standards), post-tensioned concrete, roadway expansion devices, steel stay-in-place forms, energy attenuation devices, overhead and cantilever sign structures, high mast light foundations, retaining walls and noise walls, cofferdams, and any other items when shown on the Plans.

Also submit required erection drawings for all bridge structures to be erected over active roads, railroads, and navigable waterways; drawings of falsework, bracing, cofferdams, sheeting, and bending of reinforcing steel; and other supplementary plans required by the Engineer and specified in **602.42**.

Each shop drawing sheet shall contain in the title block the following: the project number, county, bridge name, bridge number (or structure type and number), station and contract. Shop drawings whose title sheets do not include the foregoing identification will be returned for correction before any reviews for approval are conducted.

Submit shop drawings in sets with the drawing numbers running consecutively in each set, and appropriately bound if more than five sheets in a set. Do not resubmit shop drawings marked "APPROVED" or "APPROVED AS NOTED" unless specifically instructed.

Shop drawings shall be a minimum of 8-1/2 x 11 inches in size. Legible half-size copies (11 x 17 inches) of full size drawings are acceptable for submittal (see sheet format below). Submit for approval the minimum number of sets of shop drawings specified below. Only one set will be returned to the fabricator unless specifically requested and the additional set(s) requested to be returned is submitted along with those shown below. For Consultant designs, an additional set is required. For railroad structures, three additional sets are required. Submittals for the following items except structural steel girders (i.e., Bridge Girders) may be submitted electronically in *.pdf or *.tif format. Structural Steel Girders must be submitted in paper format as directed below.

Two Sets: Structural Steel (Half-size sets shall be submitted for approval. Four additional sets, two full-size and two half-size, will be required after final approval.)

Four Sets: Energy Attenuation Devices, Overhead, Cantilever Sign Structures, and Cofferdams

Six Sets: Metal Bridge Rails, Bearing Devices (shop drawings not required for plain elastomeric bearing pads), Bridge Deck Drains (shop drawings not required if fabricated according to applicable Standard Drawing), Navigation Lighting Support Brackets, Precast Prestressed Concrete Beams, Precast Prestressed Concrete Deck Panels, Precast Reinforced Concrete Beams, Precast Reinforced Concrete Box Culverts, when applicable, Post-tensioned Concrete, Roadway Expansion Devices, Steel Stay-In- Place forms, and any other type of structural shop drawing not specifically listed.

Except for Strain Poles, Street Lighting Poles, High Mast Poles with Accompanying Lowering Devices, Photometrics and Cofferdams, the fabricator shall furnish the Division of Structures with as-built shop drawings on computer disks (CDs) after the structure is complete and before final payment will be made. The drawing files on CDs shall be in either *.pdf or *.tif format. The CD case shall be labeled with the information required on the shop drawing title block.

All working drawings shall be approved by the Engineer; such approval will be general in nature and will not operate to relieve the Contractor of its responsibility under the Contract for the successful completion of the Work. In addition to such approval, working drawings involved in construction over or under railroad tracks will require approval of the railroad company before approval is granted by the Engineer. Submit four sets of plans for any cofferdams, sheeting and bracing details for bents or piers adjacent to a track, and falsework for erecting the spans over tracks, and the method of installation for the protection of the tracks, to the Engineer. Do not begin such work until these plans are approved by the Department and the Chief Engineer of the railroad. Approval of these plans will not relieve the Contractor from liability. The above also applies in connection with the installation of pipes, culverts, and other work adjacent to or under railroad tracks. The Department will not pay for the cost of preparing working drawings separately. These costs will be included in the prices of the respective Contract items involved.

Shop drawings for structural steel bridge components, precast or precast prestressed bridge, noise wall or retaining wall components and post-tensioning systems shall be accompanied on the first submittal by evidence of appropriate certification as described in **602**, **615**, **616**, and **908**.

Complete Shop Drawing, Working Drawing, or Erection Plan packages submitted for review, acceptance, or approval by the Department will be approved or denied within thirty (30) days of receipt per submittal. If revised or additional drawings are required, appropriate additional time will be allowed for review, acceptance, or approval. If the approval process exceeds thirty (30) days, the Department may extend the completion date if the delay adversely affects the critical path. When multiple drawings are submitted at the same time, each drawing must be prioritized according to the critical path submitted for the Project so as to not overload the approval process.

105.03 Conformity with Plans and Specifications

Perform all Work and furnish all materials in reasonably close conformity with the lines, grades, cross-sections, dimensions, and material requirements, including tolerances, as shown on the Plans or as specified.

If materials, or the finished product in which they are used, or various other facets of the Work, are found not to be within reasonably close conformity with the Plans and Specifications, the Engineer will determine if the Work, as performed, is in reasonably close conformity to be adequate for the basic engineering purpose. If adequate, the Engineer may accept the material or work in question subject to an appropriate adjustment in the Contract price, and the materials or work will be permitted to remain in place. If the Engineer rejects the work as unacceptable for the intended purpose, the Contractor shall remove and replace the material or work in question, at no cost to the Department in accordance with **105.12**.

If the material or work is accepted under such conditions, the Engineer will document the basis of acceptance by Change Order providing for an appropriate adjustment in the Contract price or materials as the Engineer deems necessary based on engineering judgment. If the material or work includes predetermined pay factor adjustments, the Engineer will determine the price adjustment based on the measured level of conformance to the specifications.

105.04 Coordination of Plans and Specifications

These Specifications, the Supplemental Specifications, the Plans, Special Provisions, and all other documents that are part of the Contract, are intended to be complementary and to describe and provide for a complete Contract. Requirements in one of these are as binding as if occurring in all of them. In case of discrepancy the governing order is as follows:

1. Special Provisions
2. Plans
3. Supplemental Specifications
4. Standard Specifications

In interpreting Plans, calculated dimensions will govern over scaled dimensions; Contract Plans, typical cross-sections, and approved working drawings will govern over standard sheets.

If the Contract contains technical specifications relating to utility items or building structures, and the technical specifications conflict with these Specifications, the Standard Specifications will govern when the work is performed within the roadway template, shoulder to shoulder.

Do not take advantage of any error or omission in the Plans or Specifications or of any discrepancy between the Plans, the Specifications, or any other of the Contract documents. Notify the Engineer immediately in accordance with **104.03** upon discovering any apparent error or discrepancy. The Engineer will provide an interpretation and final decision. At the Contractor's request, the Engineer will provide the final decision in writing.

105.05 Duties of Contractor

Maintain one complete set of the Contract documents, including applicable Standard Drawings, on the Project at all times. The Department will supply, without cost, two copies of the proposal form and Plans, except Standard Roadway and Structure Drawings. The Department will provide the Contractor with Standard Roadway and Structure Drawings at cost upon request.

Provide copies, in the number required by the Engineer, of all statements of proposed subcontracts. Sublet contracts in accordance with **108.01**.

Provide the Engineer with information requested by the Department related to the purchase or delivery of materials.

Give the Work the constant attention necessary to facilitate its proper progress. Cooperate with the Engineer, the Engineer's assistants and inspectors, and with other contractors in every way possible. Before starting the Work, designate in writing a representative with the authority to represent and act for the Contractor. The representative shall be present at the site of the Work at all times while work is actually in progress on the Contract. When work is not in progress or has been suspended, make arrangements acceptable to the Engineer for any emergency work that may be required. Furnish a representative irrespective of the amount of the work sublet or remaining to be performed on the Project. Whenever the representative is not present or unavailable on any particular part of the Work where it may be necessary to give direction, the Engineer may provide direction, which the superintendent or foreman who may have charge of the particular work shall receive and follow.

Designate a responsible individual as a customer service representative. This representative shall be authorized to address any customer service inquiry on the Contractor's behalf. In addition, when a Preconstruction Public Meeting is planned, the customer service representative shall attend and present the schedule and technical information regarding the Contract.

Designate a responsible individual within the Contractor organization to attend and participate in a Post Construction Project Review on all projects with an original contract bid price of $10,000,000.00 or more. The Department will conduct this review as soon as practical following the completion of the Work. The review shall be held to identify all significant project problems and make recommendations on how these problems can be avoided on future projects. Items to be discussed shall include, but are not limited to, cost overruns, Change Orders, completeness and accuracy of plans, and Contract obligations.

105.06 Planning of the Operations-Preconstruction Conference

After the Contract is fully executed and before beginning work, provide the Engineer with a complete and practicable plan of operations in accordance with **108.03**, which shall provide for the orderly and continuous performance of the Work. After submitting the plan of operation, attend a preconstruction conference arranged by the Engineer. Make available at the meeting all data necessary to substantiate the plan of operation and scheduling. When applicable, also provide the following at the conference:

1. Plan of Operation;
2. Material Suppliers List, including name and location of suppliers;
3. 24-hour emergency contact information for Traffic Control, Erosion Control, Customer Service, and Employee Safety professionals;
4. Copy of Signed Agreement between Prime Contractor and DBE Subcontractor;
5. Detouring/Controlling Traffic Plan;
6. Erosion control and storm water pollution prevention plan;
7. Traffic Control Certification Letter;
8. Proposed traffic signing diagram;
9. Contractor Employee Safety and Health Program (ESHP) Certification Letter;
10. Listing of all subcontractors and the items and/or material they are involved with; and
11. Buy America including all steel to be used including utilities, traffic and other steel components incorporated into the Project.

Ensure that all subcontractors have a safety program or participate in that of the Contractor. The Contractor is responsible for work site safety and conducting all operations to protect the workers engaged in duties connected with the Work.

In addition to this basic plan of operations, notify the Engineer of planned or contemplated operation details sufficiently in advance of starting each phase so that the Engineer may arrange for inspection. Such notice shall include the nature and location of the work planned or contemplated, the date and time of starting, and any hours outside of the conventional working day and working week during which the prosecution of such work is contemplated. Performing any work without notifying the Engineer and in the absence of inspection or a written waiver will constitute sufficient grounds for rejection of that portion of the Work.

105.07 Cooperation with Utilities, Railroads, and Pipelines

The Department will notify all utility companies, including pipeline companies, having facilities within the Project limits concerning the planned construction. The Department will make every reasonable effort to cause such parties to make the adjustments in elevation or location that may be necessary to avoid conflict with the construction and with the completed project, and to protect property from damage during construction.

In general, the Contract will indicate the various utility items known to exist, will indicate items to be adjusted or capital improvements proposed by the owners, and will designate items that are to be adjusted by the Contractor.

The location shown on the Plans for utilities are provided by the utility owners and may not be complete or accurate, especially with regard to underground installations. Contact the owners of the various utilities to determine the exact location of the utilities and the owner's schedule of any work the utility may be doing. Unless otherwise noted, the utility company or its representative will perform all utility adjustments. Cooperate with the owners of the utilities in their adjustment operations.

Provide all necessary protective measures to safeguard existing utilities from damage during construction of the Work. Correct and pay for repairs to damaged utilities that result from the Contractor's breach of the standard of care, and restore damaged facilities to their preexisting condition.

The Engineer may require advance clear cutting at any location where clearing is called for in the Plans or Specifications, and where clear cutting is necessary for utility relocation. Costs for advance clear cutting are incidental to the price bid for the clearing item specified.

If special equipment is required to work over and around the utilities, provide such equipment. The cost of protecting utilities from damage and furnishing special equipment is incidental to the price bid for other items of construction.

At least three (3) business days prior to the start of operations around the utility, notify each individual utility owner of the plan of operation, and request that they to properly locate their respective utility on the ground.

It is understood and agreed that the Contractor has considered in its bid all of the known permanent and temporary utility appurtenances in their present and relocated positions, and any proposed utility capital improvements, that the Contractor has contacted each utility owner in regard to its proposed schedule of work and that no additional compensation will be allowed for any delays, inconvenience or damage sustained due to utilities or utility adjustment. However, the Department may consider interference caused by utilities on contracts when assessing time in accordance with **108.06**.

Where construction operations require the use of a temporary crossing with the railroad or railroad companies specifically named in the proposal:

1. Request the railroad company to construct the temporary crossings and notify the railroad company 6 weeks in advance of the time the temporary crossings are to be used. This request is subject to the Contractor executing such agreements and furnishing such insurance as the railroad company may require.

2. Assume responsibility for determining and complying with the requirements of the railroad company covering the location, installation, protection, maintenance, use, and removal of such temporary crossing. Bear all costs and expenses related to the temporary crossing, including installation, protection, maintenance, and removal, contractual liability insurance, and incidental work such as drainage facilities and removal, alteration, and replacement of railroad fences.

105.08 Cooperation between Contractors

The Department reserves the right, at any time, to contract for and perform additional work on or near the Work. When separate contracts are let within the limits of a project, cooperate fully with the other contractors. Conduct the Work and place and dispose of materials so as not to interfere with or hinder the progress or completion of the portions of the Work being performed by other contractors within the project limits. Coordinate work with that of the other contractors in an acceptable manner and in proper sequence with regard to the work of other contractors. Each contractor involved shall assume all liability, financial or otherwise, in connection with its contract, and shall protect and save harmless the Department from any and all damages and claims that may develop because of inconvenience, delay, or loss experienced by any contractor because of the presence and operations of others. In the event of confusion, disagreement, or lack of cooperation between two or more contractors working within the same project limits, the Engineer will issue orders as may be necessary to coordinate the performance of all work.

105.09 Construction Stakes, Lines, and Grades

The Contractor shall cooperate in the matter of setting and preserving stakes, bench marks, lines, and grades for controlling the construction. Carefully preserve stakes and markings the Engineer may set for either its own or the Contractor's guidance. In case of negligence by the Contractor

or its employees resulting in the destruction of such stakes or markings, the Department at its discretion may deduct an amount equal to the cost of replacing the same from subsequent estimates due the Contractor.

The Department will make all measurements and surveys that involve the determination of final pay quantities, including original and final cross-sections for all earthwork.

If Construction Stakes, Lines and Grades is included in the proposal form as a bid item, the following shall apply:

1. The Engineer will locate and reference the control points, i.e. PI's and POT's as shown on the Plans along the proposed mainline, and will establish benchmarks for the proper layout of the Work. The Contractor shall locate ramps, sideroads, or similar features, make all calculations involved, and provide and place all layout stakes including those required to establish the limits of the right-of-way as shown on the Plans or as directed by the Engineer.

2. To avoid conflicts with utility installations, cooperate with the involved utility companies by timely locating highway features such as culverts, manholes, catchbasins, substructure elements of bridges, and guardrail. Provide stakes for right-of-way or slopes, ditch or stream bed grades, or other essential survey staking to prevent utility conflicts with the highway construction. Frequently, this will be required as the first item of work, and at any location on the Project as directed by the Engineer. If the Contract requires adjustment or relocation of utility facilities, all layout of this work shall be the Contractor's responsibilities.

3. Place and preserve adequate ties to all control points necessary for the accurate re-establishment of all base lines or center lines shown on the Plans, whether placed or found on the Project.

4. Use cross-sections for reference only. Check all dimensional details shown on the Plans, including elevations to ensure accuracy of the required layout. Check all bridge substructures for location, dimensional layouts, and elevations by means of two independent layout methods. Provide right-of-way or slope stakes, ditch or stream bed grades, or other essential survey staking as directed by the Engineer. Call to the Engineer's attention all errors and apparent discrepancies found in previous surveys, or in either the Specifications or the Special Provisions, for correction or

interpretation prior to proceeding with the work. Provide, set, and properly reference all stakes, references, and batter boards, including original, additional, or replacements that may be required for the construction operations. Take sole and complete responsibility for the accuracy of the line and grade of all features of the Work.

5. Where pre-splitting is specified, provide the actual longitudinal profile of the rock surface for review by the Engineer and, where applicable, for adjustment of the width of the catchment area prior to any pre-splitting activity.

6. Conduct sufficient field checks of features such as existing streams, drainage, structures, pavement elevations, and road and street tie points to ensure the proposed work on the Plans will correspond with the existing and/or proposed surroundings

7. When requested by the Engineer, provide copies of all data used in establishing line and grade for all features of work, including, but not limited to, the data used in setting and referencing all stakes and layout markings.

8. When requested by the Engineer, provide safe facilities for convenient access by Department forces to control points, batter boards, and references.

9. For all staking, use qualified engineering or surveying personnel who are trained and skilled in construction layout and staking of the type required for the Project, and who are acceptable to the Engineer. Ensure that staking is performed under the direct supervision of a Tennessee licensed Professional Engineer or a Tennessee Registered Land Surveyor experienced in the direction of such work and who is acceptable to the Engineer.

10. The Engineer may check the control of the Work, as established by the Contractor, at any time as the Work progresses. The Engineer, at any time during the Project, may request documentation, ground control, or other information as may be needed to check on the control of the Work. The Department will inform the Contractor of the results of these checks, but by so doing in no way relieves the Contractor of its responsibility for the accuracy of the layout work. Correct and replace as required, at no additional expense to the Department, any deficient layout and construction work that may

be the result of inaccuracies in layout operations, failure to report inaccuracies in layout operations, or failure to report inaccuracies found in work done by the Department or by others. If, as a result of these inaccuracies, the Department is required to make further studies, redesign, or both, all expenses incurred by the Department due to such inaccuracies may be deducted from subsequent payment estimates due the Contractor.

11. Provide all necessary personnel, engineering equipment and supplies, materials, transportation, and work incidental to the accurate and satisfactory completion of this work.

The Department will measure and pay for Construction Stakes, Lines, and Grades in accordance with **105.18** and **105.19** respectively.

105.10 Authority and Duties of Inspectors

Inspectors employed by or contracted with the Department will inspect all work done and all materials furnished. Such inspection may extend to any part or to all of the Work and to the preparation, fabrication, or manufacture of materials to be used including offsite waste and borrow areas. The Inspectors will have the authority to reject defective material and to suspend construction that is being improperly done, subject to the Engineer's final decision. Inspectors will not be authorized to revoke, alter, enlarge, or relax the provisions of the Specifications, nor will they be authorized to approve or accept any portion of the completed Project, or to issue instructions contrary to the Plans and Specifications. At the Contractor's request, the Inspector will provide written instructions on important items.

105.11 Inspection of Work

The Engineer or its representative will inspect all materials and each part or detail of the Work including waste and borrow areas. Inspection and tests are for the sole benefit of the Department and do not relieve the Contractor of the responsibility for providing adequate quality control measures, and responsibility for damage to or loss of material before acceptance. Provide access to all parts of the Work at all times and provide all information, facilities, and assistance as may be required for the Engineer to make complete and detailed inspection. All work done or materials used without supervision or inspection by an authorized Department representative may be ordered removed and replaced at no cost to the Department unless the Department representative failed to inspect after having been given

reasonable notice in writing that such portion of the Work was ready for inspection.

At any time before acceptance of the Work, the Engineer may direct the Contractor to remove or uncover portions of the Work for inspection. If examination discloses that the Work is acceptable under the terms of the Contract, restore the Work to its original condition. The Department will pay for the cost of exposing the Work for examination and of returning it to the original condition as Extra Work. If the Work exposed and examined is not acceptable for the intended purpose, the Contractor will bear the cost of uncovering, removing, and replacing all of the material involved, and restoring the Work in accordance with the Specifications and Plans.

When any unit of government or political subdivision or any railroad corporation is to pay a portion of the cost of the Work covered by the Contract, its respective representatives will have the right to inspect the Work. Such inspection will not make any unit of government or political subdivision or any railroad corporation a party to the Contract, and in no way interferes with the rights of either party hereunder.

If the Contractor fails to comply with any order of the Engineer made under the provisions of this Subsection, the Engineer will have authority to repair or replace unacceptable work and deduct the costs from any monies due the Contractor. If monies due or to become due the Contractor are not sufficient to defray the costs of such repairs or replacements, then the Department will hold the Contractor's Surety liable for the costs incurred. Any Construction performed by the Department under these provisions will not waive any provisions of the Contract nor relieve the Contractor in any way from the responsibility for the Work.

105.12 Removal of Unacceptable and Unauthorized Work

If the Engineer rejects portions of the Work found to be unacceptable in accordance with **105.03**, or found to be unacceptable prior to final acceptance of the Work due to poor workmanship, the use of defective materials, or damage through carelessness, the Contractor shall immediately remove and replace this work in an acceptable manner.

The Department is not obligated but may consider payment for work under the Contract for the following reasons:

1. Work that has been done without lines and grades having been given by the Engineer or established by the Contractor's forces, if appropriate,

2. Work done contrary to the instructions of the Engineer,

3. Work done beyond the lines shown on the Plans or as given,

4. Unauthorized work or Extra Work done without the Engineer's authority, or

5. Work performed without an approved subcontract.

The Engineer may direct the Contractor to remove or replace such work at no cost to the Department.

105.13 Completion of Specific Sections of a Project

The Department may require a specific section or sections of a Project to be completed and accepted before completion of the entire Project. Such section(s) shall be a reasonable length, as determined by the Engineer, and completed in full accordance with the Contract. When sections are completed, the Engineer, after final inspection, will accept the section(s) and relieve the Contractor of any further work or maintenance costs for the accepted section(s). The acceptance of a section or sections of a Project shall in no way waive or alter any of the terms of the Contract.

After any offsite waste and borrow area(s) are no longer needed, ensure that the disturbed area is stabilized according to the TN NPDES Construction General Permit criteria or the agreed upon Reclamation Plan. After the area has reached final stabilization, request a meeting with the Engineer to perform a final inspection. Once the Engineer deems the area acceptable, terminate Contractor obtained permits.

105.14 Opening Sections of a Project to Traffic

If directed by the Engineer, open certain sections of the Project to traffic even if they are not fully completed. If the paving, including the connections through the structures, is completed on any of the sections involved, the Engineer, after final inspection, may accept the pavement and relieve the Contractor of further maintenance expense in connection with the section. If the pavement is not fully completed on any of the sections ordered opened, the Contractor shall maintain the paving in accordance with

104.05. In either case, the Contractor shall maintain the other portions of the Work in the same sections of the Project according to the Contract.

105.15 Acceptance

Upon due notice from the Contractor of presumptive completion of the entire Project, the Engineer will make an inspection. If the Engineer finds that all construction provided for and contemplated by the Contract is satisfactorily complete, then the inspection will constitute the final inspection and the Engineer will make the final acceptance and notify the Contractor in writing of this acceptance effective on the final inspection date.

If, however, the inspection discloses any work not in close conformity with the Plans and Specifications, in whole or in part, the Engineer will instruct the Contractor to correct the unsatisfactory work. The Contractor shall immediately comply with and execute such instructions. After correction of the Work, the Engineer will make another inspection, which shall constitute the final inspection, provided the Work has been satisfactorily completed. If satisfactory, the Engineer will make the final acceptance and notify the Contractor in writing of this acceptance to be effective on the final inspection date. Final acceptance under this subsection does not waive any of the Department's legal rights under **107.19**.

If exclusive offsite waste and/or borrow area(s) were used as part of the Project, the Engineer will not start the process for final acceptance of the Project until the Contractor provides proof of permit termination for all waste and/or borrow area(s). If the Contractor wishes to continue use of the waste and/or borrow area(s), provide the Engineer with a letter indicating the intended use and updated documentation.

105.16 Claims for Adjustment and Disputes

A. Notice of Intent to File a Claim

If the Contractor has requested additional compensation, time, or both under **104.02** and **108.07**, has provided notification in accordance with **104.03**, and the Engineer has denied the request for a change to the Work, the Contractor may provide notice of intent to file a claim. The Contractor shall provide such notice in writing within thirty (30) calendar days of receiving the Engineer's decision.

After filing the notice of intent to file a claim, the Contractor shall maintain adequate records related to the claim, including records of the disputed labor, equipment and materials, and, if applicable, monthly schedule updates showing critical path delays to the completion date. Update and disclose this information to the Department monthly. The Department may audit claim records at any time. Unless the Engineer suspends in writing the affected work, the Contractor shall continue to perform the disputed work. If such notification is not given, or if the Engineer is not given sufficient opportunity for keeping strict account of the Contractor's actual costs, then the Contractor waives any claim for additional compensation. Such notice by the Contractor and the Engineer's accounting of the cost shall not in any way prove or substantiate the validity of the claim. Nothing in this Subsection shall be construed as establishing any claim contrary to the terms of **104.02**.

B. Informal Claim Meeting

Upon written request by the Contractor submitted with its notice of intent to file a claim, and within thirty (30) days of such request, the Department will afford the Contractor an opportunity to informally discuss the disputed matters with a Department official having the authority to resolve the dispute. The Contractor may use this opportunity to present relevant information and respond to any information provided by the Engineer or other Department officials with knowledge of the Work. Proceedings in the Informal Claim Meeting are an attempt to mutually resolve a claim without litigation and are not admissible for any purpose in any proceeding contemplated in this Subsection **105.16** or any formal administrative hearing.

C. Submission of Claim

Within ninety (90) calendar days after submitting the notice of intent to file a claim, or within ninety (90) days of the completed disputed Work, whichever is later, or such time agreed upon by the parties in writing, the Contractor shall submit a complete claim package. The claim package shall include all documents supporting the claim and provide sufficient detail to enable the Department to ascertain the basis and amount of claim. If requested by the Contractor, the Department may extend the ninety (90) day period in writing. As a minimum, the following information shall be submitted with each claim:

1. A claim certification containing the language shown in **Figure 105.16-1** for direct claims by the Contractor, or **Figure 105.16-2** for pass-through claims, as appropriate.

2. A detailed factual statement of the claim for additional compensation, time, or both, providing all necessary dates, locations, and items of work affected by the claim;

3. The date on which facts were discovered that gave rise to the claim;

4. The specific provisions of the Contract that support the claim and a statement of the reasons why such provisions support the claim;

5. If an extension of contract time is sought, a schedule analysis as required by **108.07**; and

6. If additional compensation is sought, the amount and specifics of the compensation.

CONTRACTOR'S CLAIM CERTIFICATION

Under penalty of law for perjury or falsification, the undersigned, (Authorized Representative)_____, (title)_____, of (company)_____, hereby certifies that the claim of

$_____for extra compensation and ____ Days additional time, made herein for work on this Contract:

(1) Is true and made in good faith

(2) The supporting data is accurate and complete;

(3) The claim is fully supported under the Contract between the parties; and

(4) The claim amount accurately reflects the Contractor's actual incurred costs or delay.

I have reviewed the documents submitted and know the facts and information to be true based upon my personal knowledge and belief.

This claim package contains all available documents that support the claims made herein and I understand that no additional information, other than for clarification and data supporting previously submitted documentation, may be presented by me.

Dated _____/s/_____

Subscribed and sworn before me this __ day of_____ _____.

_____

NOTARY PUBLIC

My Commission Expires: _____

Figure 105.16-1: Contractor's Claim Certification

PASS-THROUGH CLAIM CERTIFICATION

Under penalty of law for perjury or falsification, the undersigned, (Authorized Representative)_____, (title)_____ (company), hereby certifies that the claim of

$_____ for extra compensation and ___ Days additional time, made herein for work on this Contract:

(1) Is true and made in good faith

(2) The supporting data is accurate and complete;

(3) The claim is fully supported under the Contract between the parties; and

(4) The claim amount accurately reflects the Contractor's actual incurred costs or delay.

I have reviewed the documents submitted and know the facts and information to be true based upon my personal knowledge and belief.

This claim package contains all available documents that support the claims made herein and I understand that no additional information, other than for clarification and data supporting previously submitted documentation, may be presented by me.

Dated _____/s/_____

Subscribed and sworn before me this __day of _____.

_____

NOTARY PUBLIC

My Commission Expires: _____

Dated _____/s_____

The Contractor certifies that the claim being passed through to TDOT is passed through in good faith and is accurate and complete to the best of my knowledge and belief.

Dated _____/s/_____

Subscribed and sworn before me this __ day of _____.

_____

NOTARY PUBLIC

My Commission Expires: _____

Figure 105.16-2: Pass-Through Claim Certification

D. Department Decision

When the Contractor properly files a claim and allows for reasonable and timely access to the Contractor's books and records, the Department will review the claim and render a written decision to the Contractor to either affirm or deny the claim, in whole or in part, within sixty (60) calendar days after receipt of the claim package or at such time agreed upon by the parties.

The Department will assemble and maintain a claim record consisting of all information submitted by the Contractor in support of the claim and all other information considered by the Department in reaching a decision. Once the Department assembles the claim record, the submission and consideration of additional information or data, other than for clarification and support of previously submitted documentation, will not be permitted. The Department will provide a copy of the claim record and the written decision to the Contractor describing the information considered by the Department in reaching a decision and the basis for that decision.

If the Department decides to affirm the claim, an adjustment will be made in accordance with **108.07** and **109.04** as applicable. If the Department denies the claim, the Contractor may either accept the Department decision as final or file a written appeal to the Department's authorized representative identified in the final decision letter within sixty (60) calendar days from the receipt of the Department decision.

If a written appeal is not properly or timely filed, the Engineer's decision is final and binding, and the Contractor waives any further rights to pursuing the claim.

If the Department fails to render a written decision within sixty (60) calendar days after receipt of the claim package, or within any extended time period as agreed to by the parties, the Department will send written notice to the Contractor that the decision period has ended and that the Contractor's time period for written appeal has begun.

E. Appeal Process

When a claim is appealed in writing, the Department will provide the claim record to the duly authorized representative responsible for review of the appeal. Within fifteen (15) calendar days after the

submission of the appeal, either party may submit a written request for a hearing with the duly authorized representative. The duly authorized representative will review the claim and render a decision to affirm, overrule, or modify the Department decision within sixty (60) calendar days or such time agreed upon by the parties after receiving the written appeal.

The Department will not consider any new information that was not previously made a part of the claim record, other than clarification of the previously submitted documentation. The Contractor shall have sixty (60) calendar days to accept or reject the duly authorized representative's decision. The Contractor shall notify the Department of its acceptance or rejection in writing. If the Contractor accepts the duly authorized representative's modification of the Department's decision, the modified decision will be implemented with a Change Order in accordance with the applicable Contract provisions. If the Contractor disagrees with the modified decision, the Contractor may pursue a claim for the disputed compensation.

If the Department agrees that the Contractor is due additional compensation, time, or both, but the Department and the Contractor cannot agree on the amount, the Department may issue a Change Directive for the amount determined to be fair and reasonable by the Department. The Contractor may then pursue a claim for the disputed compensation.

The Contractor may file a claim with the Claims Commission. The parties understand and agree that the Contractor's failure to bring suit within one-hundred-eighty (180) calendar days, or such other time agreed upon by the parties, shall be deemed an acceptance of the duly authorized representative's decision and a complete bar to any such claims or causes of action based on the claim.

105.17 Alternative Equipment

Although certain Specification Sections may specify use of equipment of a particular size and type, or use of certain methods to perform portions of the Work, it is to be understood that the development and use of new or improved equipment or methods are encouraged.

The Contractor may request, in writing, permission from the Engineer to use equipment of a different size or type in place of the equipment

specified. The Contractor may request to use new methods in the same way.

If the Engineer grants such permission, it shall be understood that permission is granted for the purpose of testing the quality of work actually produced by such equipment or method and is subject to continuous attainment of results that are equal to, or better than that which can be obtained with the equipment or method specified. The Engineer will withdraw such permission at any time if it is determined that the alternative equipment or method is not producing work that is equal, in all respects, to that which can be produced by the equipment and methods specified. Upon withdrawal of such permission by the Engineer, the Contractor shall use the equipment or method originally specified, and remove and dispose of or otherwise remedy, at no additional cost to the Department, all defective or unsatisfactory work produced with the alternative equipment or method.

The Contractor shall not pursue any claim against the Department for either withholding or granting permission to use alternative equipment or methods or for the withdrawal of such permission.

The Engineer will only grant permission to use alternative equipment in place of equipment specified where such equipment is new and improved, or more adaptable to the work being performed. The approval for use of particular equipment on any project should not in any way be considered as an approval of the use of such equipment on any other project. The Engineer will grant permission to use alternative methods under the same rules governing equipment.

COMPENSATION

105.18 Method of Measurement

The Department will measure construction Stakes, Lines and Grades as a percentage of the lump sum price bid for the completion of the work specified in **105.09** and partial payment will be made according to the schedule in Table 105.18-1.

Table 105.18-1: Payment Schedule for Construction Stakes, Lines and Grades

Estimate Number or Percent of Total Contract Amount of Previous Estimate	Total Percent of Construction Stakes, Lines, and Grades Lump Sum Bid Item
Estimate # 1	20%
Estimate # 2	40%
10%	50%
20%	60%
40%	70%
60%	80%
80%	100%

105.19 Basis of Payment

The Department will make partial payments for Construction Stakes, Lines and Grades on the basis of a percentage of the lump sum price bid in accordance with the schedule shown in Table 105.18-1.

Such payment is full compensation for furnishing, setting, maintaining, and resetting, when necessary, the stakes, and for providing all labor, equipment, materials, and incidentals to complete the work as specified.

SECTION 106 – CONTROL OF MATERIALS

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106.01 Quality of Materials

Only use materials in the Work that conform to all of the Contract quality requirements. Control and incorporate materials to produce completed construction that conforms to and is fully acceptable under the terms of the Contract.

Where reference is made in the Contract to certain manufacturers' materials or products, it is not the intent to preclude the use of others, but rather to establish minimum acceptable design standards. The Contractor may substitute material and products of other manufacturers provided they are equal to or better than the minimum design standards and are approved by the Department.

106.02 Material Information

When the Department has readily available test reports on materials from local sources near the Project, it will furnish copies to the Contractor covering each source for which a specific request is made. In furnishing such reports, the Department will not be responsible for materials failing to conform to the test reports either as to quality or quantity.

106.03 Local Material Sources

If the Contractor desires preliminary tests of local materials, it shall deliver samples of the materials to the Laboratory. The Department will test such samples, up to a reasonable number, and in such time as the work load in the Laboratory may permit. Acceptable test results on preliminary samples will not guarantee acceptance of materials from the same source later.

106.04 Sampling and Testing, or Inspection

Incorporate into the Work only those materials that have been sampled and tested, inspected, and approved by the Engineer. Untested or unaccepted materials used in the Work without the Engineer's written permission shall be removed and replaced at no cost to the Department. Unless otherwise specified, sampling and testing, or inspection will be conducted by qualified representatives in accordance with the most current published national standard specifications, AASHTO or ASTM methods on the date of the Advertisement. Furnish all materials for samples at no cost to the Department. The Department will perform sampling and testing, or inspection, at its expense unless otherwise specified. If the Department does not elect to sample and test or inspect at the source, it will sample and test, or inspect, materials after delivery to the site or to the batching plant. Furnish all facilities, and provide all reasonable assistance to secure and transport samples, and move materials being inspected.

The Departmental procedures will provide sampling and testing frequencies for the acceptance, quality control, independent assurance, verification, or certification for materials and products.

The Engineer may accept certain materials or products and assemblies based on Certificate of Compliance signed by the manufacturer or its authorized representative, stating that such materials, products, and assemblies fully comply with the requirements of the Contract. For each lot of such materials or assemblies delivered to the Work, provide a Certificate of Compliance that clearly identifies the lot. Provide all necessary paperwork with certification submittals as specified in Departmental Procedures.

Furnish a notarized Certificate of Compliance for a non-bid item, not permanently incorporated in the Work, but that must meet a designated specification upon delivery of the material to the Project and prior to its being used.

The Department may sample and test materials, products, or assemblies accepted on the basis of Certificate of Compliance at any time, and may reject such materials and assemblies if found to be in non-conformance with the Contract.

106.05 Source or Plant Inspection

The Contractor is entirely responsible for securing satisfactory material. However, if the volume of any given material, the progress of construction, and other considerations of interest to the Department so justify, the Department may inspect materials at the source of supply. The Department will undertake such inspection only when the Engineer is assured of the fullest cooperation and assistance of the Contractor and of the material producer involved. Provide required copies of all orders, shipping information, and other pertinent papers.

Provide the representatives of the Department with free and safe access at all times to parts of the site or plant concerning the manufacture and production of material for the Project. If the Contractor is not the owner of the place where fabrication, preparation, or manufacture is in progress, the plant owner is deemed to be the agent of the Contractor with respect to the obligation assumed hereunder.

106.06 Field Laboratory

Furnish Type A or Type B laboratory(s) or both, as required to be used exclusively for testing purposes. Provide suitable field laboratories or inspection offices at batch plants and sources or plants at which off-site inspection is provided by the Department under **106.05**. Locate the laboratory(s) as directed by the Engineer. Install, equip, and make building(s) ready for use before the Contractor's operations require field testing. When a concrete batch plant is located near a Type B Laboratory used for testing at an asphalt plant, the Engineer may approve joint use provided there is ample time and equipment to perform all necessary testing for both operations.

All Contractor and producer laboratories must be inspected and qualified in accordance with TDOT procedures before the Contractor can perform any work.

A. Type A

Provide a Type A Laboratory consisting of a building, room, or dedicated area having at least 120 square feet of floor area with a minimum width of 8 feet and a minimum height of 7 feet. Provide laboratory space that is floored, roofed, sealed inside, weather-tight, and furnished with electricity. Furnish the space with adequate work benches, cabinets, and drawers. Provide suitable heat and air conditioning, and equip the laboratory with a laboratory oven capable of maintaining a temperature of 230 °F ± 9 °F. Provide lights, electrical outlets, and adequate ventilation for the tests being performed.

When the determination of aggregate gradation is required, furnish the following equipment:

1. Scales of appropriate capacity and design to weigh the required samples. Scales are to be sensitive to within 0.2% of the sample to be weighed. Provide standard weights for scale calibration.

2. Screens of appropriate size and mesh to separate the samples into the required series of sizes. Woven wire cloth shall conform to AASHTO M 92. Screens for running gradations of coarse aggregates shall have a minimum area of 2.33 square feet.

3. A mechanical shaker approved by the Engineer and suitable for running both coarse and fine aggregate.

4. Facilities to perform wash tests according to AASHTO T 11 that include an adequate and suitable water supply.

B. Type B

In addition to meeting all of the requirements for a Type A Laboratory, a Type B Laboratory shall be equipped with the following:

1. Laboratory space with a minimum of 300 square feet.

2. Two vacuum extractors, each having a minimum bowl capacity of 100 troy ounces meeting the requirements of ASTM D2172, or one vacuum extractor and one ignition

furnace meeting the requirements of AASHTO T308. Supply an adequate amount of an approved solvent from the Department's Qualified Products List and provide for storage and disposal of the waste solvent in accordance with the regulations promulgated under the Tennessee Hazardous Waste Management Act.

To ensure adequate ventilation, house the extractor and drying equipment in an enclosed hood. Equip the hood with an exhaust fan vented to the outside and mounted at the appropriate location in order to remove the vapors of the solvent. Where the extractor is installed outside the laboratory, only vent the drying equipment as outlined above.

3. Supply apparatus meeting the requirements of AASHTO T 166, Section 3.1 and 3.2 for determining the bulk specific gravity of compacted asphalt mix. When required by the Contract, supply an apparatus meeting the requirements of AASHTO T 209, Section 3.1 through 3.5 for determining the maximum specific gravity of an asphalt mix.

4. Supply a minimum of two suitable thermometers with an approximate temperature range of 50 to 400 °F.

5. Provide a furnace capable of performing loss on ignition tests for a minimum 10-troy ounce sample.

6. When required as specified in **407.03**, provide equipment needed to perform Marshall Tests according to AASHTO T 245. The compactor shall be a Marshall Mechanical type with rotating mold(s) and slanted foot hammers that produce a modified kneading action.

Unless otherwise specified in the Contract, the Department will not pay for Field Laboratories as a separate item but will consider it incidental to the applicable contract items.

106.07 Notice of Source or Arrival of Materials

Purchase all materials sufficiently in advance of incorporating into the Work to allow the Engineer to conduct sampling and testing, or inspection. Provide the Department, in writing, the name and location of suppliers that will furnish materials for the Project. When the Department does not elect

to perform materials sampling and testing, or inspection at the source, advise the Engineer in writing within 24 hours after materials requiring sampling for testing, or inspection, are delivered to the site of the Work.

106.08 Handling and Storage of Materials

Transport all materials in tight, clean vehicles, and prevent contamination, segregation, or other damage to the materials when in route to the job site or the batching plant, and when moved from point to point at later stages.

Store materials to preserve their quality and fitness for use. When considered necessary, store materials in weatherproof buildings, place them on wooden platforms or other hard, clean surfaces but not on the ground, and cover them when directed. Locate stored materials to facilitate prompt inspection. Do not use private property for storage purposes without written permission of the owner or lessee. If using portions of the right-of-way for storage of materials or erection of batching plants, obtain the specific approval of the Engineer.

106.09 Resampling and Testing, or Reinspection

At the option of the Engineer, the Department may resample and test all materials or re-inspect at any time after delivery to the site, or to any batching plant. If such materials are found to be unacceptable, the Department will reject the materials.

106.10 Defective Material

Do not deliver to the site materials found to be unacceptable or rejected elsewhere. Remove rejected materials from the site or processing batch plant at no cost to the Department.

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107.01 Laws to be Observed

Keep fully informed and comply with all of the following that affect the conduct of the Work or those engaged or employed on the Work: Federal and State laws, local laws and ordinances, regulations, and all orders and decrees of bodies or tribunals having jurisdiction or authority related to the Work.

Protect and indemnify the State and its representatives against claims or liability arising from or based on the violation of any such law, ordinance, regulation, order, or decree, whether by the Contractor, its employees, subcontractors and suppliers, or any others engaged by the Contractor.

Should the Contractor's unapproved activities relating to the performance of the Work be in violation of any of the above laws or regulations and cause fines and/or penalties to be assessed against the Department, the Department may deduct all fines and penalties from monies due the Contractor.

107.02 Load Restrictions on Projects Under Construction

A. Delivery of Materials

The gross weight of trucks delivering material to construction projects shall be governed by State Law as set forth in Tennessee Code and Federal Law. Conspicuously display the tare weight, the allowable gross weight for State Highways, and the allowable gross weight for the Interstate System on the side of all delivery trucks. Use the Bridge Formula to determine allowable Interstate System gross weights as defined in the FHWA's publication, *Bridge Formula Weights*.

Do not operate equipment of excessive weight or loading that may cause damage to structures, the roadway, or to any other type of construction. Limit the hauling of materials over the base course or surface course under construction as directed by the Engineer. Do not load a concrete pavement, base, or structure before the expiration of the cure period. Assume responsibility for all damage done by equipment used in construction of the Project.

Where it is necessary to haul material over a structure without a posted load limit, limit the gross loads to the weights listed below. Do not exceed the loads posted for structures with weight limitations unless adequate shoring is provided and written permission is granted by the Department's Division of Structures.

Maximum axle load .....20,000 pounds
Maximum load per axle on tandem axles .....17,000 pounds
Maximum total load.....80,000 pounds

Place approved temporary guides on the bridge floor, as directed by the Engineer, to position the wheel loads directly over the bridge girders as

nearly as possible. Keep the bridge floor free of debris to reduce impact forces. Limit the maximum speed to 15 miles per hour.

Once hauling over the bridge is complete, clean the bridge floor, curbs, and rail in a manner acceptable to the Engineer.

B. Construction Loads

Construction loads include all material, component, equipment, and personnel loads applied to the roadway or structure other than those attributable to permanent elements of the roadway structure in their final state of construction. Do not place any construction loads that are non-essential to the active construction work on roadways or structures. Limit the hauling of materials over the roadway base course or surface course under construction as directed by the Engineer. Construction loads are not allowed on concrete pavements, base, or structures before the end of the curing period. For concrete structures without posted load limitations, refer to **604.28** for construction loading limitations and requirements applied to these bridges or structures.

107.03 Permits, Licenses, and Taxes

Obtain all permits and licenses, pay all charges, fees, and taxes, and give all notices and submit all paperwork necessary and incidental to the due and lawful prosecution of the Work, except those permits and licenses that the Department is required to obtain.

107.04 Patented Devices, Materials, and Processes

Provide suitable legal agreement with the patentee or owner for any design, device, material, or process covered by letters of patent or copyright used in the construction of the Work. The Contractor and the Surety shall indemnify and save harmless the State, any political subdivision within the State, or any affected third party from any and all claims for infringement by reason of the use of any such patented design, device, material, process, trademark, or copyright. Indemnify the State for costs, expenses, and damages that it may be obligated to pay by reason of an infringement, during the prosecution or after the completion of the Work.

107.05 Restoration of Surfaces Opened by Permit

The right to construct or reconstruct any utility service in the highway, road, or street that is under construction or reconstruction as part of the Project, or

to grant permits for same, is expressly reserved to the Department for the proper authorities of the municipality or other governing units in which utility work is done. During the life of the Contract, allow parties bearing such permits, and only such parties, to make openings in the pavement. Permits, in general, will require the utility companies to restore the Work to the condition that existed prior to the utility adjustment. When restoration is not made by the utility and when directed by the Engineer, make all necessary repairs due to such openings in a manner acceptable to the Engineer. The Department will make payment for such restoration at the unit prices for Contract items applicable to the work, or as Extra Work as provided for under **104.02** and in accordance with **109.04**. The Department will not pay for any damages associated with the digging up of the street or right-of-way or for any delay occasioned by the restoration.

107.06 Federal Aid Provisions

1. When the United States Government pays for all or any part of the Project cost, observe the Federal laws and the rules and regulations made pursuant to such laws. Allow for the inspection of the Work by appropriate Federal Agencies. Such inspection will not make the Federal Government a party to this Contract, and will in no way interfere with the rights of either party.

2. Comply with Section 106 of the National Historic Preservation Act for all waste and borrow areas outside the Project right-of-way. Furnish the Engineer and the Environmental Division with an Archaeological Clearance certified by the State Historic Preservation Office at least thirty (30) calendar days before starting work on all non-commercial material sources requiring excavation or fill.

3. Regardless of prior certification, if prehistoric remains or human burial sites are encountered at any time during construction, suspend operations and immediately notify the Engineer and the State Historic Preservation Office.

4. Comply with Section 7 of the Endangered Species Act for all waste and borrow areas outside the Project right-of-way. Furnish the Engineer and the Environmental Division with Threatened and Endangered Species Clearance from the Tennessee Wildlife Resource Agency and the U.S. Fish and Wildlife Service at least thirty (30) calendar days before starting work on all waste and borrow sites located outside the Project right-of-way.

107.07 Bridges over Navigable Waters

Conduct all work in or over navigable waters so as to not interfere with the free navigation of the waterways and not impair the existing navigable depths except as allowed by permit issued by the U.S. Army Corps of Engineers or the U.S. Coast Guard.

Comply with all provisions and requirements set forth in all applicable permits. Direct all required correspondence with the Coast Guard, or such agency as may have jurisdiction, through the office of the Engineer. Provide all Contractor required permits to the Engineer before beginning work in or over navigable waters.

Comply fully and faithfully with the various requirements established by the Corps of Engineers, the Coast Guard, and other agencies that may have jurisdiction over the work in and over navigable waters applicable to the Contract, and which may not be covered by existing permits. Such work may include, but not necessarily be limited to, dredging, location and safeguards for cofferdams and temporary falsework, anchorage of barges and construction equipment, temporary restriction of channel width, lighting during construction, and removal of all temporary construction.

107.08 Environmental Protection

A. Protection of Streams, Lakes and Reservoirs

Exercise every reasonable precaution throughout the life of the Project to prevent silting of rivers, streams, and impoundments (lakes, reservoirs, and similar). Construct drainage facilities as well as other Contract work that will help control siltation in conjunction with earthwork operations or as soon thereafter as is practicable.

Before suspending construction operations for any appreciable length of time, shape the top of earthwork to allow the runoff of water, and construct temporary earth berms along the top edges of embankments to intercept runoff water. Construct temporary erosion and sediment control measures deemed necessary by the Engineer in the immediate vicinity of rivers, streams, or impoundments. Comply with the provisions and requirements of all the applicable permits. Maintain these temporary measures, which may include berms, dikes, slope drains constructed of concrete, metal, or wood, or stabilized by paving or covering with waterproof materials, or sedimentation basins, until

the permanent drainage facilities and erosion control features are complete and operative.

Obtain necessary permits related to operations not covered by the Plans, including use of waste and borrow sites. Obtain necessary permits for offsite staging areas. Determine if additional permits or modifications to existing permits are required to complete the Work as shown on the Plans.

The Department will acquire the necessary permits related to waters of the United States as defined in 33 CFR Part 323 or "waters of the State," as defined in TCA §69-3-108 for construction indicated on the Plans. These permits will govern the Contractor's method of construction. Permit modifications will be allowed only when required to complete the Work shown on the Plans. Permit modification will not be allowed for Contractor convenience. The Department may assist in the acquisition of additional permits or permit modifications when deemed necessary to complete the Work shown on the Plans.

Unless otherwise approved in writing by the Engineer, restrict construction operations in rivers, streams, and impoundments to permitted areas necessary to complete the Work as indicated on the Plans and in the field SWPPP. Comply with the provisions and requirements of all the applicable permits. Do not perform in-stream work where a channel change is required until after the new channel has been completed and the water diverted to the new channel. As soon as practicable, clear rivers, streams, and impoundments of all falsework, temporary piling, debris, or other obstructions placed therein or caused by the construction operations.

Provide temporary bridges or other structures in accordance with all permits when crossing live streams with construction equipment.

The location, permitting, and use of waste and borrow sites, other than commercially operated sources, shall be subject to the requirements of the Department's manual *Procedures for Providing Offsite Waste and Borrow on TDOT Construction Projects*.

Exercise every reasonable precaution throughout the life of the Project to prevent the discharge of any substance into the waters of the State or to place or cause any substance to be placed where it, either by itself or in combination with other substances, may cause harm, potential harm, or detriment or damages by alteration of the physical, chemical,

biological, bacteriological, or radiological properties of such waters. Prevent changes in temperature, taste, color, turbidity, or odor as will result or likely result in harm, potential harm, or detriment to the public health, safety, or welfare, or the foregoing to the health of animals, birds, fish or aquatic life, or render or will likely render such waters potentially less useful for domestic, municipal, individual, agricultural, recreational, or other reasonable uses, or leave or will leave such waters in such condition as to violate any Federal, State, and local standards of water quality. Do not discharge pollutants such as chemicals, fuels, lubricants, bitumens, raw sewage, and other harmful materials into or alongside of rivers, streams, and impoundments or into natural or manmade channels leading thereto. If a discharge as described above occurs, stop the Work, notify the Engineer, and the Tennessee Department of Environment and Conservation, Water Pollution Control, and take immediate actions to contain and remediate the discharge. Perform containment and remediation work at no cost to the Department.

If the Work involves painting or texturing bridges over the waters of the State, before starting such work, submit to the Engineer for approval a proposed remedial plan to contain and remove accidental discharges into the water. On the receipt of this proposed plan, the Department will assign an Inspector to ensure adherence to these Contract requirements. The Inspector will have full authority to suspend any work that is not in compliance with the Contract.

Conduct and schedule operations so as not to interfere with the movement of migratory fish as indicated in the Plans or permits.

Unless otherwise provided for in the Contract, the work described herein will be considered incidental to various Contract items.

B. Forest Protection

In carrying out work within or adjacent to State or National Forests, or other wooded areas, comply with all regulations of the State Fire Marshal, Division of Fire Prevention, Department of Commerce and Insurance of the State, or other authority having jurisdiction, governing the protection of forests and work within forests, and observe all sanitary laws and regulations when performing work in forest areas. Keep the areas in an orderly condition, dispose of all refuse, obtain permits for the construction and maintenance of all construction camps, stores, warehouses, residences, latrines, cesspools, septic tanks, and

other structures in accordance with the requirements of the Forest Supervisor.

Take all reasonable precautions to prevent and suppress forest fires and require employees and subcontractors, both independently and at the request of Forest officials, to do all that is reasonably within their power to prevent and suppress and to assist in preventing and suppressing forest fires. Make every effort to immediately notify a Forest official of the location and extent of any fire discovered.

C. Hazardous or Toxic Waste

When the Contractor's operations encounter or expose any abnormal condition that may indicate the presence of hazardous or toxic waste, discontinue such operations in the vicinity of the abnormal condition and immediately notify the Engineer in accordance with **104.03**. The presence of barrels; discolored earth, metal, wood, and similar; visible fumes; abnormal odors; excessively hot earth; smoke; or other conditions that appear abnormal may be indicators of hazardous or toxic wastes and shall be treated with extraordinary caution. Do not resume operations until so directed by the Engineer.

Dispose of all hazardous or toxic waste encountered during construction in accordance with the requirements and regulations of the applicable Federal, State, and local laws.

For necessary work performed to dispose of hazardous or toxic waste, the Department will make payment at the unit prices for Contract items applicable to such work, or as Extra Work under **104.02** and in accordance with **109.04.**

D. Air Pollution Responsibilities

Comply with all Federal, State, and local air pollution control rules, regulations, ordinances, and statutes that apply to work performed pursuant to the Contract, including, but not limited to, applicable air pollution control rules, regulations, ordinances, and statutes specified in the Tennessee Department of Environment and Conservation's (TDEC) Air Pollution Control Regulations and municipal regulations pertaining to air pollution.

Notify the TDEC Division of Air Quality Control a minimum of ten (10) days prior to demolition of any bridge or major structure.

107.09 Sanitary Provisions

Provide and maintain in a neat, sanitary condition accommodations for employees as may be necessary to comply with the requirements of the State and local Boards of Health, or of other bodies or tribunals having jurisdiction.

107.10 Safety

A. Public Convenience and Safety

Conduct the Work at all times to ensure the least possible obstruction to traffic. Provide for the safety and convenience of the general public and the residents along the highway, and for the protection of persons and property as specified in **104.04**, **104.05**, **104.06**, and **104.08**.

B. Employee Safety and Health Program

The Contractor is responsible for work site safety and conducting all operations so as to protect the workers engaged in duties connected with the Work. Provide an Employee Safety and Health Program (ESHP) at the preconstruction conference that meets or exceeds all Federal, State, and local safety and health standards and is certified by the safety professional responsible for developing the ESHP. Certification of the ESHP is required before any work can begin. Maintain an original copy of the ESHP and provide to the Department upon request.

The Contractor is responsible for implementing, monitoring, updating, and revising the ESHP. Describe in detail how the ESHP is implemented and monitored. Provide guidelines for protecting personnel from hazards associated with project operations and activities. Establish the policies and procedures for safety practices that are necessary for the Work to be in compliance with the requirements of TOSHA, the MUTCD, and other State and Federal regulatory agencies with jurisdiction, rules, regulations, standards, or guidelines in effect at the time the Work is in progress. If an incident occurs that requires hospitalization or TOSHA Citation to be submitted, send notification of the incident to the Engineer and forward to the Regional Safety Coordinator.

All workers within the right-of-way shall wear head protection meeting current ANSI requirements. Also, all workers within the right-of-way

shall wear high-visibility safety apparel. High-visibility apparel shall be considered personal protective clothing that meets performance Class 2 or Class 3 of the ANSI/ISEA 107-2004 publication. Class 3 apparel shall be required for night work.

107.11 Use of Explosives

When using explosives, exercise the utmost care not to endanger life or property, and comply with applicable Federal, State, and local laws regarding the use of explosives, including new work. Assume responsibility for all damage resulting from the use of explosives.

As required by State law, notify each property owner and public utility company having structures or facilities in proximity to the Work before using explosives. Provide such notice sufficiently in advance to allow owners to protect their property from damage.

107.12 Promptness of Performance

These Specifications, and orders issued by the Engineer, describe actions, which in many cases, if not performed promptly by the Contractor, may result in danger to life or property, loss to the Department, or delay to the Work. If the Contractor fails to act with appropriate or required promptness, the Engineer may, with written notice, have the necessary act performed by others. In such case, the Department will deduct the costs involved from monies due or to become due the Contractor or may proceed in accordance with **108.10**.

107.13 Legal Responsibilities of the Contractor

In addition to the specific legal responsibilities set forth in **107.01** through **107.11**, the Contractor is charged with other broad legal responsibilities under these Specifications. These responsibilities include but are not limited to various areas as follows:

1. To perform the Work in accordance with all Contract terms.

2. To maintain traffic in accordance with **104.04**, including the use of all proper and necessary protective devices and procedures.

3. To conduct all operations so as to protect the members of the general public, residents near the Project, workmen engaged in or on the Work, and representatives of the State, the Federal

Government and railroads, while they are engaged in duties connected with the Work. This responsibility also extends to the protection of public and private property under all circumstances.

4. To hold harmless and defend against all claims of any nature arising out of or resulting from the performance of the Work, the State, any political subdivision thereof, and all employees of the State, and the Federal Government, provided that such claim, damage, loss or expense is attributable to bodily injury, sickness, disease or death, or to injury or destruction of tangible property (other than the Work itself), but only to the extent caused by the negligent acts or omissions of the Contractor, a subcontractor, or anyone directly employed by them for whose acts they may be liable. This responsibility generally extends to innocent third parties.

5. To pay just claims for materials, supplies, equipment, tools, labor, injury or damage to persons or property, and all other items, against the Contractor or any subcontractor or supplier in connection with the Work.

Be fully familiar with these responsibilities and with the many others that are stated in the Contract; and make certain that all things required to be performed are performed so as to fulfill the responsibilities involved and that all appropriate and required precautions are taken at all times.

107.14 Contractor's Responsibility for Work

Until final written acceptance of the Project by the Engineer, maintain charge and care of the Work, and take every precaution against injury or damage to any part thereof by the action of the elements or from any other cause, whether arising from the execution or the non-execution of the Work. Rebuild, repair, restore, and make good all injuries or damages to the Work occasioned by any of the above causes before final acceptance, and bear the expense thereof, except for damage to the Work due to unforeseeable causes beyond the control of and without the fault or negligence of the Contractor, including but not limited to, acts of nature, the public enemy, or governmental authorities.

For damage to acceptably installed items of Work caused by the traveling public on sections of the Project open to traffic, the Contractor shall repair the Work at the applicable Contract unit price. An acceptably installed item shall be complete in place meeting the required specifications. For this

purpose, limit the acceptably installed items of Work to the following items used for safety and traffic control: traffic signal systems, signs, lighting, guardrail, impact attenuators, median barriers, parapet rails, and permanent pavement markings. If the damage to the above items necessitates only minor repairs, perform the work in accordance with **109.04.C** or as directed by the Engineer.

107.15 Liability Insurance

In addition to any other forms of bonds or guaranties or insurance required under the Contract, when any part of the Work is to be constructed on railroad-owned property, procure and maintain liability insurance coverage of the kinds and amounts, and in the manner stipulated in the Special Provisions of the Contract. If a Special Provision is not stipulated in the Contract, coordinate with the railroad to determine the disposition of railroad protective insurance and any associated flagging. The costs involved in furnishing the insurance specified will not be paid for directly but will be incidental to other items of Work.

107.16 Right-of-Way

The Department will secure all necessary right-of-way in advance of construction unless specified in the Contract with an availability date. The Contractor shall waive any and all claims for interference, delay, or damage if it accepts a limited work order or unconditional work order to proceed with the construction knowing that the right-of-way have been only partially secured or that the right-of-way are still encumbered.

107.17 Personal Liability of Public Officials

In carrying out any of the provisions of these Specifications, or in exercising any power of authority granted to them by or within the scope of the Contract, the Commissioner, Engineer, or their authorized representatives have no liability either personally or as officials of the State. It is understood that in all such matters they act solely as agents and representatives of the State.

107.18 Claims Against the Department

No claims against the Department will be considered except those filed in accordance with **105.16**.

107.19 No Waiver of Legal Rights

The Department will not be precluded or estopped from correcting any measurement, estimate, or certificate made either before or after the completion of the Work or by final acceptance of the Work in accordance with **105.15**, nor from showing that the Work or materials do not in fact conform to the Contract. The Department may recover from the Contractor or its Sureties, or both, such overpayment or damages as it may sustain or damages due to the Contractor's failure to comply with the terms of the Contract. The Department will retain and apply monies owed to the Contractor under any contract or claim, and will recover by process of law such sums in order to correct any error or make good any defects in the Work or materials.

The following Department actions do not operate as a waiver of the Department's rights or powers under the Contract or rights to damages or other relief:

1. Acceptance by the Department, or any representative of the Department;
2. Payment for or acceptance of the whole or any part of the Work;
3. Extension of Contract time; or
4. Possession of the Work taken by the Department.

A waiver by the Department of any breach of the Contract shall not be held to be a waiver of any other or subsequent breach. The Contractor, without prejudice to the terms of the Contract, shall be liable to the Department for latent defects, fraud, or such gross mistakes as may amount to fraud, or as regards the Department's rights under a warranty or guarantee.

107.20 Certified Payrolls

As specified by Department procedures for the Contractor and subcontractor workforce, submit certified payrolls to the Engineer each week in which any work is performed. Once construction begins, if in any week the Contractor or subcontractor does not perform work, submit the following statement to the Engineer: "No work performed by (contractor name) for the week ending _____."

107.21 Quarantine Restrictions - Pest Control

Agricultural pests such as Soybean Cyst Nematode, Fire Ant, and Japanese Beetle have infested certain areas in several southeastern states including

Tennessee. The Plant Pest Control Division of the U.S. Department of Agriculture and the Tennessee Department of Agriculture restrict the movement of certain items from infested areas to prevent the spread of these pests to non-infested areas.

For all hay, straw, or other baled plant material coming from Imported Fire Ant (IFA) Quarantine areas in Tennessee or from states other than Tennessee, provide a permit from that state's Department of Agriculture or other appropriate regulatory agencies. The permit shall state that material has been inspected and found to be free of IFA.

Soil and construction equipment operating in regulated areas are subject to plant quarantine regulations. In general, these regulations provide for the cleaning of equipment before it is moved from regulated areas. Complete information may be secured from State or Federal plant pest control inspectors. It will be the responsibility of the Contractor to comply with all rules and regulations established by the Tennessee Department of Agriculture.

Contractors working in quarantine areas should contact the above agency at an early date in order not to delay the inspection and movement of equipment from an infested area.

SECTION 108 – PROSECUTION AND PROGRESS

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108.01 Subletting of Contract

Do not sublet, allow second tier sublet, sell, transfer, assign, or otherwise dispose of the Contract or any portion thereof or a right, title, or interest in the Contract without the Engineer's written consent. If the Engineer consents to subletting or second tier subletting a portion of the Contract, the Contractor shall self-perform work amounting to not less than 30% of the total original Contract cost. For items designated in the Contract as "specialty items," the Contractor may sublet or second tier sublet this work and deduct the cost of such specialty items from the total original cost before computing the amount of the Work required to be self-performed by the Contractor with its own organization.

When portions of the Contract are to be sublet, the Contractor shall furnish all statements of proposed subcontracts on the proper form with the required number of copies. The Department must approve each proposed subcontract or tiered subcontract before that particular subcontract is put into effect. Upon request, the Department will furnish the proper prequalification forms to the Contractor.

As a part of this proposal the Contractor agrees as follows:

1. No personnel will work on the Project under the terms of this Contract except legal employees and legal employees of official subcontractors.

2. Contractor books and records will be available for inspection by State or Federal auditors at any time to confirm the above requirement.

The Contractor shall incorporate the provisions of the preceding two paragraphs into all subcontracts. Violation of these terms may subject the Contractor or subcontractors to suspension from eligibility to bid on construction projects, at the Commissioner's discretion.

Subletting or transferring the Contract will not release the Contractor from liability under the Contract and bonds.

108.02 Beginning of Construction

Do not begin the Work before receipt of the Work Order. The Work Order will stipulate the expected start date for construction and the date from which Contract time will be charged.

108.03 Prosecution of Construction

Plan and execute the Work in a manner to meet the required Contract time set forth in the Proposal. Provide adequate manpower, equipment, and materials in accordance with the plan of operations and scheduling requirements described herein so that construction of the various items or groups of items can be carried out and completed within the Contract time based on a completion date or dates, or calendar or working days.

The following Progress schedules will be required at a minimum:

A. Project Durations Less Than 90 Days

Submit a plan of operation with sufficient detail to show the sequence and location of operations and the period of time required for completion of the portion of the Work under each item or group of like items. Indicate in a plan of operations the manpower and equipment required to handle the phases of the Work. The Engineer will use a straight-line curve to determine progress.

B. Project Durations 90 Days to 24 Months

At the preconstruction meeting, submit a base line bar chart to the Engineer for review. The baseline bar chart progress schedule shall include the following:

1. Activities that describe the essential features of the Work, activities that might delay Contract completion, and controlling activities;

2. The planned start and completion dates for each activity, the duration of each activity in work days, and the sequencing of all activities. If activities have durations of more than one update period, break into two or more activities distinguished by location or some other feature.

3. Dates related to the procurement of materials, equipment, and articles of special manufacture; and dates related to the submission of working drawings, plans, and other data specified for review or approval by the Department;

4. Dates related to key Department inspections; and

5. Dates related to specified activities by the Department and third parties.

Include as part of the schedule a narrative listing the quantity and estimated daily production rate for controlling activities, number of work days per week, holidays, number of shifts per day, and number of hours per shift. For calendar day or completion date contracts, provide an estimated number of adverse weather days for each month.

The Engineer and Contractor will review the draft baseline schedule at the preconstruction conference. The Engineer will accept the baseline schedule, provide review comments, or request additional information. As necessary, make appropriate adjustments or provide additional information. The Department may withhold payments or only make payments for the value of materials in accordance with **109.08** until the Engineer accepts the baseline schedule. The Engineer's acceptance is based solely on whether the schedule meets the requirements of this Section **108.03**. Review comments made by the Engineer on the baseline schedule will not relieve the Contractor from compliance with the Contract.

The Contractor is responsible for scheduling, sequencing, and prosecuting the Work to comply with Contract requirements. The cost of preparing and updating the schedule is incidental to all Contract items.

Conduct periodic job site meetings with the Engineer monthly or as required by the complexity of the Project to assess progress. Update the schedule on a monthly basis to reflect actual progress and to document approved Contract Change Orders. Include the actual start and finish of each activity, percentage complete, the remaining duration of activities started and ongoing, and a summary of schedule changes. Submit the schedule updates to the Engineer for review within 48 hours after the job site meeting.

C. Project Durations Greater Than 24 Months or When Required By Contract

Develop a Critical Path Method (CPM) schedule using computerized scheduling software.

1. **Baseline CPM Schedule.** Within fifteen (15) calendar days after the Notice to Proceed, submit a draft baseline CPM schedule to the Engineer and hold a meeting to review. Define and sequence activities so as to accurately describe the Project and to meet Contract requirements, the scope of work, phasing, accommodations for traffic, and interim, milestone, and project completion dates. Use working days to create the schedule, beginning with the date of the Notice to Proceed. Ensure that the CPM schedule identifies and includes the following:

    a. Planned start and completion dates for each activity;

    b. Alphanumeric coding structure and activity identification system;

    c. Duration of each activity (stated in work days, and with activities of more than one update period or thirty (30) work days in duration broken into two or more activities distinguished by location or some other feature);

    d. Finish-to-start relationships among activities, without leads or lags, unless otherwise approved by the Engineer;

e. Interim, milestone, and project completion dates specified in the Contract as the only contractual constraints in the schedule logic;

f. The critical or longest path identifying the controlling activities of the Work;

h. Activities related to the procurement of materials, equipment, and articles of special manufacture;

i. Activities related to the submission of working drawings, plans, and other data specified for review or approval by the Engineer;

j. Activities related to Department inspections and approvals; and

k. Specified activities performed by the Department, subcontractors, suppliers, and third parties such as utilities and railroads.

Float is defined as the amount of time between the date when an activity can start (early start), and the date when an activity must start (late start). Float is a shared commodity between the Contractor and the Department, and either party has full use of the float until it is depleted. Do not use float suppression techniques, such as preferential sequencing (arranging critical path through activities more susceptible to a Department-caused delay), special lead/lag logic restraints, zero total or free float constraints, extended activity times, manipulated calendars, or constraint dates other than required by the Contract.

2. CPM Schedule Submission Requirements. Submit one hard copy and one electronic copy of the schedule to the Engineer, and provide the following items with each schedule submission:

a. A logic diagram in color, depicting no more than 50 activities on each 11 x 17 inch sheet, and with each sheet including title, match data for diagram correlation, and a key;

b. Tabular sorts of activities by early start, predecessor and successor, work area by early start, and total float;

c. 60-day look-ahead bar charts by early start; and a

d. Narrative report indicating the approach to sequencing the work, the critical or longest path, potential conflicts that may affect the schedule and how they might be mitigated, workdays per week, holidays, number of shifts per day, number of hours per shift, equipment use, and how the schedule accommodates adverse weather days for each month.

The Engineer and Contractor will review the draft baseline CPM schedule at the preconstruction conference. The Engineer will accept the draft baseline CPM schedule, provide review comments, or request additional information. Make appropriate adjustments or provide additional information. The Department may withhold payments or only make payments for the value of materials in accordance with **109.08** until the Engineer accepts the baseline CPM schedule. The Engineer's acceptance is based solely on whether the baseline schedule meets the requirements of **108.03**. Review comments made by the Engineer on the initial schedule will not relieve the Contractor from compliance with the Contract. The Contractor is responsible for scheduling, sequencing, and prosecuting the Work to comply with the Contract requirements. The cost of preparing and updating the schedule is incidental to all Contract items.

3. Schedule Updates. Update the schedule on a monthly basis to show current progress. Include the following with each update:

a. Actual start and finish dates of each activity or remaining durations of activities started but not yet completed;

b. Updated critical or longest path; and

c. Narrative report with summary describing progress during the month, shifts in the critical activities from the previous update, sources of delay, potential problem areas, work planned for the succeeding update period, and changes made to the CPM schedule. Changes include additions, deletions, or revisions to activities due to the issuance of a change order, changes to an activity duration, changes to relationships between activities, or

changes to the planned sequence of work or the method and manner of its performance.

Submit the updated schedule electronically to the Engineer. Also provide tabular sorts by total float and activity by early start.

D. Schedule Revisions

The Engineer will determine the progress of the Contract by either the time versus money straight line method or the schedule updates submitted by the Contractor. If actual construction falls behind the plan of operations or schedule by more than 15%, offer for approval a revised schedule that reflects timely completion. Otherwise, the Engineer may request a revised schedule. Circumstances that may lead to such a request include the following:

1. A delay (actual or projected) to scheduled milestone or project completion dates 15% or more behind schedule;

2. A difference between the actual sequence or duration of work and that depicted in the schedule; and

3. The issuance of a Change Order that alters the planned sequence of work or the method and manner of its performance by adding, deleting, or revising activities.

Prepare and submit the revised schedule within ten (10) calendar days after the Engineer's request. The Engineer may accept the revised schedule, reject the revised schedule, or request additional information. Address the reasons for rejection or submit the information requested no more than ten (10) calendar days after the Engineer's request.

If the Contractor cannot justify the unsatisfactory progress, the Department may remove the Contractor from the Department's list of qualified bidders in accordance with **102.01**. In addition to the Contractor, any affiliated or subsidiary companies, companies in which the Contractor holds a significant interest, and companies in which officers or stockholders hold a significant interest will be removed from the Department's list of qualified bidders. The Department will give appropriate written notice to the Contractor.

The Department will not reinstate a Contractor disqualified from bidding until the Department considers the progress satisfactory or until

the Contract(s) is completed and accepted, whichever occurs first. The above sanction will remain in effect until rescinded by the Department.

Do not stop prosecution of the Work without the written consent of the Engineer. If the Work is stopped, give 24 hours' notice to the Engineer before resuming operations. Unless provided for in the Contract, conduct night work only with the Engineer's written permission.

108.04 Character of Workers; Methods and Equipment

A. Workers

Employ, at all times, satisfactory labor and equipment for prosecuting the required classes of work to full completion in the manner and time specified. The Engineer may direct the Contractor in writing to discharge any personnel 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 who is disrespectful, intemperate, disorderly, or otherwise objectionable. Such personnel shall not be employed again on the Work.

Do not engage the services of any person or persons who are, or have been, during the period of the Contract, in the employment of the Department, except regularly retired employees, without the Engineer's written approval. In addition, do not engage the services of any firm or any principal officer or employee of a firm that participated in the development of the design of the Project to be constructed under the Contract.

B. Methods and Equipment

Provide equipment of sufficient size and mechanical condition to produce a satisfactory quality of work and meet the time schedule in the plan of operations. During the course of construction, maintain all equipment in satisfactory operating condition. The Engineer may order the Contractor to remove from the Work equipment that becomes less than satisfactory. Do not use equipment that will damage any portion of the Work, or other property, either public or private.

When the methods and equipment for accomplishing the construction are not specified in the Contract, use any methods or equipment that will accomplish the work in conformance with the Contract requirements.

When construction methods and equipment are specified, use such methods and equipment unless the Engineer authorizes alternative methods or equipment in accordance with **105.17**. The Department will not change the basis of payment for the Contract items or time as a result of the substitution of methods or equipment.

108.05 Temporary Suspension of Construction

If it should become necessary to temporarily suspend construction for an undefined period, store all materials so as not to obstruct or impede the traveling public and to prevent damage to the materials. During the suspension, take every precaution to prevent damage or deterioration of the Work; provide suitable drainage of the road by opening ditches, shoulder drains, and other similar measures; and erect temporary structures where necessary.

108.06 Determination of Time for Completion

Complete the Work in accordance with **104.01** and **105.03** within the number of working days or calendar days, or by the completion date specified in the Contract.

A. Working Days

For working day contracts, the Contract time consists of the number of working days specified to completion. The Engineer will assess working days and apprise the Contractor, monthly, of the number of accumulated working days charged against the Contract. File any protest in connection with working day charges within five (5) working days of receipt of the Engineer's assessment. The Engineer will review such protest and the supporting information and will render a decision either affirming or correcting, in writing, the accumulated number of working days previously reported.

B. Calendar Days or Completion Date

For calendar day contracts, the Contract time consists of the number of calendar days stated in the Contract counting from the effective date of the Engineer's order to commence with the Work, including all Sundays, holidays and non-work days to completion. For completion date contracts, complete the Work on or before the fixed calendar date specified in the Contract.

The Engineer will extend the Contract time for completion for the number of calendar days elapsing between the effective dates of any orders of the Engineer to suspend work and to resume work for Engineer-ordered suspensions, or for excusable delays in accordance with **108.07**.

108.07 Determination of Contract Time Extensions and Excusable Delays

A. General

The Engineer will extend the Contract time or completion date only if an excusable delay, in accordance with **108.07.B** and **108.07.C**, affects the critical path of the Work shown on the accepted progress schedule.

Time extensions will be evaluated using the most recently submitted and accepted project schedule in accordance with **108.03**. Notify the Engineer in accordance with **104.03** and submit a written request for a time extension including a schedule update with an analysis showing the impact of the delay on the critical path and documentation to support this request.

If the Engineer finds that the Work was delayed because of conditions beyond the control and without the fault of the Contractor, and the request is justified, the Engineer will extend the time for completion by a properly executed Change Order in such amount, either calendar days or working days, as properly supported by the schedule analysis. The extended time for completion will be in full force and effect as though it were the original time for completion.

If the Project does not require a schedule in accordance with **108.03**, and satisfactory fulfillment of the Contract requires a change to the Work in accordance with **104.02**, which may require a time extension, the Engineer will evaluate the Contractor's request and determine whether the change has affected the completion of the Project. If the change resulted in an increase in quantities for a major item of work, as defined in **101.03**, the Engineer may proportionally increase the Contract time allowed for performance of the major item of work.

If the Project contains an incentive provision for early completion and the Engineer has extended the Contract time or completion date, the incentive date for early completion will not be adjusted unless otherwise allowed in the Contract or approved by the Engineer.

B. Excusable, Non-Compensable Delays

Excusable, non-compensable delays are delays that are not the fault of either the Contractor or the Department. The Department will not provide additional compensation for excusable, non-compensable delays. The following are causes for non-compensable delays:

1. **Cataclysmic Natural Phenomena.** Floods, fires, tornadoes, earthquakes, or other natural cataclysmic phenomenon of nature where a Declaration of Emergency has been declared for the affected area of the State.

2. **Extreme or Adverse Weather.** Unusually severe weather for an extended period of time that greatly exceeds weather pattern history as determined by the Engineer.

3. **Utilities or Government Agencies.** Delays caused by utilities or government agencies unless caused by the failure of the Department to follow the procedures set forth in TCA §54-5-801 *et seq*.

4. **Shortage of Materials.** Extraordinary delays in material deliveries that the Contractor cannot foresee resulting from freight embargoes, government acts, or area wide material shortages.

5. **Labor Disputes.** Delays from labor strikes that are beyond the Contractor's, subcontractor's, or supplier's power to settle and not caused by improper acts or omissions of the Contractor or subcontractors.

If the Contractor incurs liquidated damages pursuant to **108.09** and if the Department extends the Contract time for an excusable, non-compensable delay, the Department will relieve the Contractor from associated liquidated damages under **108.09** commensurate with the time extension.

C. Excusable, Compensable Delays

Excusable, compensable delays are delays affecting the critical path of Work that are determined to be the result of changes in the Work in accordance with **104.02**.

If the Contractor incurs liquidated damages pursuant to **108.09** and if the Department extends the Contract time for an excusable, compensable delay, the Department will relieve the Contractor from associated liquidated damages under **108.09** commensurate with the time extension. The Department will determine compensation for delay in accordance with **109.06**.

D. Concurrent Delays

Concurrent delays are separate critical delays that occur at the same time. When an excusable, non-compensable delay is concurrent with an excusable, compensable delay, the Contractor is entitled to additional time but not entitled to additional compensation. When a non-excusable delay is concurrent with an excusable delay, the Contractor is not entitled to a time extension or additional compensation.

108.08 Final Acceptance

The Engineer will make final acceptance in accordance with **105.15** and the following:

A. State Funded Projects

Upon presumptive completion of the Project and due notice from the Contractor, the Engineer will make an inspection. If all items of work are satisfactorily completed, the Engineer will accept the Project and stop time charges as of the date of the inspection. However, if the inspection reveals that some items of work remain to be completed, the Engineer will direct the Contractor to complete these items and continue charging time until all Work has been satisfactorily completed, regardless of the number of inspections required prior to final acceptance.

B. Federal-Aid Projects

The procedure for Federal-aid projects will be the same as noted above for wholly State funded projects except that time charges will be suspended during the time interval between presumptive acceptance by the Engineer and the date of inspection by the FHWA. Should the FHWA find any work unsatisfactory during the inspection, the Engineer will resume time charges from the day after the inspection date until the work is corrected. In the event further inspections by

FHWA are required, the procedure described herein will be repeated until final acceptance of the Project.

108.09 Failure to Complete the Work on Time

For each calendar day over and above the stipulated completion date on which any portion of the Work remains incomplete, the Department will deduct a sum of money from monies due the Contractor, not as a penalty but as liquidated damages. The amounts to be deducted shall be as specified in Table 108.09-1.

Table 108.09-1: Liquidated Damages for Failure to Complete the Work on Time

Original Contract Amount ($)			Daily Charge ($/day)
0	to	500,000	250.00
> 500,000	to	1,000,000	420.00
> 1,000,000	to	2,000,000	740.00
> 2,000,000	to	10,000,000	1,000.00
>10,000,000	to	20,000,000	1,600.00
>20,000,000			1,800.00

Allowing the Contractor to continue and finish the Work or any part of it after the completion date, or after the date to which the time for completion may have been extended, will in no way waive the rights of either party under the Contract.

108.10 Termination of the Contract

A. Default

The Department reserves the right to terminate, by a written Contract Termination Notice, any Contract, of which these Specifications are a part, if the Contractor:

1. Fails to begin construction in accordance with the terms of the Work Order;

2. Fails to furnish sufficient labor or proper materials, or to use proper construction methods and equipment;

3. Performs the Work improperly and fails to remove and replace portions of the Work that are found to be unsatisfactory;

4. Discontinues prosecution of the Work without the Engineer's consent, or fails to resume operations at any time ordered to do so;

5. Fails to maintain traffic in a safe and efficient manner, or to maintain completed portions of the Work effectively;

6. Fails to maintain a rate at which construction progress, in the Engineer's opinion, is sufficient to ensure completion of the Work within the specified time;

7. Fails, in any degree, to maintain the same financial responsibility on the basis of which the Department pre-qualified the Contractor for submitting a proposal for the Work and awarded the Contract; or

8. Fails or refuses to follow the proper orders of the Engineer.

Under any such circumstance, the Engineer will serve written notice on the Contractor and its Surety of intent to terminate the Contract for reasons that will be set forth therein. If within fifteen (15) days of delivery of such notice, the Contractor and its Surety, or the Surety has not taken sufficient steps to satisfy the Engineer of the correction of the circumstance at fault, the Department may, in its absolute discretion, order the Contract terminated.

The Department may then appropriate or use any or all materials and equipment on the ground as may be suitable and acceptable and may enter into an agreement for the completion of the Contract according to the terms and provisions thereof, or use such other methods as in the opinion of the Engineer will be required for the completion of the Contract in an acceptable manner.

The Department will deduct from any monies due or which may become due the Contractor, all costs and charges incurred by the Department, together with the cost of completing the Work under Contract. If such costs exceed the sum that would have been payable under the Contract, then the Contractor and the Surety shall be liable and shall pay to the Department the amount of such excess.

The Department will not relieve the Contractor and the Contractor's Surety of the liability for liquidated damages assessed in accordance with **108.09** because of the default.

If it is determined that the Department's default of the Contractor is improper, the default will revert to a termination for convenience, and the Department will compensate the Contractor in accordance with **109.05.B**.

B. Without Fault

The Department may, by a written Contract Termination Notice, with the approval of the FHWA where applicable, terminate any contract or a portion thereof after determining that for reasons beyond the control of the Contractor, the work contracted for cannot be completed. Such reasons for termination may include, but need not necessarily be limited to, one of the following:

1. An Executive Order of the President of the United States with respect to the prosecution of war or in the interest of national defense.

2. The Engineer and Contractor each make a determination that, due to a shortage of critical materials required to complete the Work caused by allocation of these materials to work of a higher priority by the Federal Government or any agency thereof, it will be impossible to obtain these materials within a practical time limit and that it would be in the public interest to discontinue construction.

3. An injunction is imposed by a court of competent jurisdiction that stops the Contractor from proceeding with the Work and causes a delay of such duration that it is in the public interest to terminate the Contract and the Contractor was not at fault in creating the condition that led to the court's injunction. The Engineer's decision as to what is in the public interest and as to the Contractor's fault, for the purpose of termination, shall be final. Restraining orders or injunctions obtained by a third party citizen action resulting from Federal or State environmental protection laws, or where acts or omissions or persons or agencies whether or not the Contractor primarily caused the issuance of such order or injunction, shall also be cause for termination.

C. Convenience

The Department may, by a written Contract Termination Notice, with the approval of the FHWA where applicable, terminate any contract, or any portion thereof for the Department's convenience, when the Engineer determines that a termination is in the best interest of the Department.

The Department may terminate the Contract for convenience at any time after the Department has made a determination to award a contract. Reasons for termination may include, but are not limited to:

1. Insufficient funds by the Department due to extenuating circumstances;

2. Occurrence of an environmental situation of a significant nature that would require extensive and time-consuming delays in the work for the purposes of identification, evaluation, and possibly mitigation;

3. Occurrence of a previously undiscovered error in the bid documents; and

4. Any other circumstances the Department determines to be in the best interest of the Department or the public.

In addition to the general reservation of the right to terminate for convenience under this Subsection, the bidding documents may provide for a termination of the Contract for convenience under this Subsection upon the occurrence or non-occurrence of a specified event after bid opening.

Under any of the above circumstances for termination, the Engineer will deliver to the Contractor and the Surety a written Contract Termination Notice for reasons that will be set forth therein. The Notice shall specify the extent to which performance of work is terminated under the Contract and the effective date of termination. Unless otherwise directed by the Engineer, upon receipt of a Contract Termination Notice, the Contractor, or its Surety, shall immediately:

1. Stop work as directed in the Notice;

2. Place no further orders or subcontracts for materials, services or facilities except as approved by the Engineer to complete work not terminated;

3. Terminate all orders and subcontracts for the terminated work.

4. Deliver to the Engineer completed or partially completed plans, drawings, information and other property required to be furnished under the Contract;

5. Take actions that the Engineer directs to protect and preserve Contract-related property that is in the possession of the Contractor in which the Department has or may acquire an interest;

6. Provide all other information included in this section and as requested by the Engineer; and

7. Complete all work not terminated.

If the Department terminates the Contract or any portion thereof before completion of all items of work in the Contract, the Department will make payment for the actual number of units of items of work completed at the Contract unit prices and as mutually agreed for items or work partially completed in accordance with **109.05**. The Department will not pay claims for loss of overhead or anticipated profits, including anticipated earnings on usage of owned equipment, and impact, delay, or other direct or indirect costs resulting from this termination as part of any settlement. The Department will pay for items that are eliminated in their entirety by the termination in accordance with **109.05**.

The Department may purchase 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. Submit the proof of actual cost, as shown by receipted bills and actual cost records. The Engineer, as shown by actual cost records, may designate all actual costs for delivery at such points of delivery to be added to this cost. If the Engineer and the Contractor do not agree to purchase such materials, the Department may reimburse the Contractor for any reasonable restocking fees and handling costs incurred by the Contractor in returning unused materials to the vendor. If only portions

of the Work are eliminated, the Department may stop delivery and payment for unnecessary materials.

Termination of a Contract or a portion thereof shall not relieve the Contractor of its responsibility for the completed work or work not included in the Notice of Termination, nor shall it relieve the Surety of its obligation for and concerning any just claims arising out of the work performed or remaining to be performed.

SECTION 109 – MEASUREMENT AND PAYMENT

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109.01 Measurement of Quantities

The Engineer will measure all work completed under the Contract according to United States standard measure, using measurement methods and computations conforming to sound engineering practice.

The Engineer will measure actual quantities of work completed as described in the subsections entitled "Method of Measurement" for specific items of work. The Department will make payment based on these actual measured quantities. Accept estimated quantities designated in the Contract to be used as final payment quantities for the final payment, unless revised by approved Change Order.

If there is a disagreement between the Contractor and the Department concerning the measured quantity of any pay item, the Department will re-measure the item provided the Contractor enters into a Change Order to bear the expense of the re-measurement should it show no substantial change in the pay item quantity. The definition of "substantial change" will be stated in the Change Order and will depend on the item being checked and the nature of the particular Project.

The Engineer will measure completed work as follows:

A. Lump Sum or Each

The term "lump sum" or "each" when used as a unit of payment will mean full compensation for all resources necessary to complete the item.

B. Length

The Engineer will measure items paid by the linear foot such as pipe culverts or guardrail along the finished surface of the item parallel to the item base or foundation, unless otherwise shown on the Plans.

The Engineer will measure timber by the 1,000 feet board measure (MFBM) actually incorporated in the structure based on nominal widths and thicknesses and the extreme length of each piece. The Engineer will measure timber piling by the linear foot.

A Station when used as a definition or term of measurement is 100 linear feet.

C. Area

Unless otherwise specified, the Engineer will make longitudinal measurements for surface area computations along the actual surfaces and not horizontally, and will make no deductions for individual fixtures having an area of 9 square feet or less. Unless otherwise specified, transverse measurements for surface area computations will be the neat dimensions shown on the Plans or as directed in writing by the Engineer.

D. Volume

The Engineer will measure structures according to neat lines shown on the Plans or as altered to fit field conditions as directed by the Engineer.

In computing excavation volumes, the Engineer will use the average end area method or other methods commonly accepted as standard practice in the industry.

For materials to be measured by volume in the vehicle, haul the material in vehicles of a size or type approved by the Engineer. Ensure

that the body shape of vehicles used for this purpose allows that the actual contents can be readily and accurately measured. The Engineer will measure materials at the point of delivery.

When requested by the Contractor and approved in writing, the Engineer may weigh the materials and convert mass to cubic yards for payment purposes. The Engineer will determine the volume to weight conversion factors. The Engineer and the Contractor must agree to the conversion factors in writing before this method of measurement of pay quantities is used.

The Engineer will measure bituminous materials by the gallon or ton. Volumes will be measured at 60 °F or, when measured at other temperatures, will be corrected to the equivalent volume at 60 °F according to ASTM D1250 for asphalts or ASTM D633 for tars.

E. Weight

The term "ton" will mean the short ton consisting of 2,000 pounds avoirdupois.

The Engineer will measure cement by the ton.

Unless otherwise specified, the Engineer will accept certified weights for materials measured or proportioned by weight that are shipped by rail or truck transport, provided that only the actual weight of the material used is paid for.

For bituminous materials, net certified scale weights or weights based on certified volumes in the case of rail or truck transport shipments, unless otherwise specified, will be used as a basis of measurement, subject to correction when bituminous material has been lost, wasted, or otherwise not incorporated in the Work.

In all cases where measurement of materials is based on certified weights, provide the Engineer with certified weigh bills showing the net tons of materials received in each shipment. The Engineer will not pay for materials in excess of the amounts represented by the certified weigh bills.

Employ a Certified Public Weigher as defined in the Certified Public Weigher Law of 1981, Tennessee Code Annotated, Section 47-26-801, et seq., as amended. The Engineer will measure all applicable

materials in accordance with the Certified Public Weigher Law and Department policy on scales approved by the Engineer. Provide weight (haul) tickets in accordance with Department policy and as directed by the Engineer.

Provide a standard brand of platform truck scales with a sufficient rated capacity to weigh the maximum gross load to which they will be subjected. Do not use truck scales to measure weights in excess of the manufacturer's rated capacity. Clearly post the manufacturer's rated capacity on the scale manufacturer's plate and in the shelter provided for the weigher.

At the time of installation or modification of existing scales, test the scales before using to ensure they are within the allowable tolerances. Use a qualified scale technician to perform any alteration (e.g., electrical readout) or change in the rated capacity. Document all changes or alterations made by the scale technician and furnish a copy of the documentation to the Department.

House the recording mechanism of the scale in a suitable shelter furnished with adequate light, heat, chairs, tables, and storage drawers as needed for the convenience of the weigher. In addition, keep the scale platform and scale pit free of debris that could affect the accuracy of the scales.

Provide digital readout and scale printers as the primary weight indicator or as accessory equipment. The Department will inspect and approve all scale control and recording equipment.

Ensure the scale's accuracy within a tolerance of 0.5% and with a minimum graduation value not greater than 100 pounds. Provide a straight approach at each end of the platform scale in the same plane as the platform and of sufficient length and width to ensure the level positioning of vehicles longer than the scale platform during weight determinations. Weigh each truck and trailer with no brakes set on any wheel. Locate the scale platform so that surface water will drain away from it and to allow for an adequate foundation of concrete or other approved materials. Construct the foundation of sufficient strength and durability to withstand repeated capacity loading without affecting the accuracy of the scales.

Check the scales as often as necessary to ensure their continued accuracy. If the scales cannot be checked within the time frame set by

Department policy, the Engineer may give tentative approval, based on check truckloads weighed on other scales that are approved by the Department or other State agency.

Trucks used to haul material being paid for by weight shall be weighed empty at such times as the Engineer directs, and each truck shall bear a plainly legible identification mark.

Due to possible variations in the specific gravity of aggregates, the tonnage used may vary from the proposal quantities and the Department will not make adjustments in the Contract unit price because of such variations.

The cost of providing facilities and equipment for the accurate weighing, proportioning, or measuring of materials is incidental to the associated pay items in the Contract.

109.02 Scope of Payment

The Department will pay, and the Contractor agrees to accept, the compensation provided in the Contract for the work acceptably completed and measured for payment under each Contract item. Payment of a Contract item is full compensation for furnishing all materials, equipment, tools, labor, and incidentals required to complete the item; and for all risk, loss, damage, or expense arising out of the nature or the performance of the work, subject to **107.19**.

If the "Basis of Payment" clause in the Specifications relating to a unit price in the bid schedule requires that the price of the Contract item cover and be considered compensation for certain work or material essential to the item, the Department will not measure or pay for this same work or material under any other pay item that may appear elsewhere in the Specifications.

When two or more projects are included in the same Contract, the Contractor will be required to furnish any item listed in the Contract to any or all of the projects at the Contract unit price.

The Department requires that the Contractor pay subcontractors promptly for their work after receipt of payment for the associated work from the Department. The Contractor shall pay each subcontractor and material supplier for work performed or materials supplied under its subcontract no later than thirty (30) calendar days from the date the Contractor receives

payment for the work from the Department. The same prompt payment requirements apply to subcontractors at all tiers.

Provide a monthly payment certification to the Department entitled "Prompt Payment Certification Form." An officer of the Contractor shall sign this certification form. The Department will withhold estimate payments if the required information is not submitted or if subcontractors, at any tier, or materials suppliers are not paid after the thirty (30) calendar day time period. Also, all required certifications must be submitted to the field office and accepted before such work is deemed satisfactorily completed. Any delay or postponement of payment beyond the thirty (30) calendar day time frame will result in accrual of interest as provided under TCA §12-4-707(b).

The prime contractor, or subcontractors, at any tier, shall not withhold any retainage from progress payments made to their subcontractors.

Document on the Prompt Payment Certification Form the actual amount paid to any certified Disadvantaged Business Enterprise (DBE) or certified Small Business Enterprise (SBE) during the estimate period for which the certification is being made.

109.03 Compensation for Altered Quantities

When the accepted quantities of work for Contract items vary from the quantities in the bid schedule, the Department will pay in full at the original Contract unit prices for the accepted quantities of work measured in accordance with **109.01**. The Department will not make any price adjustment for variations in quantities except as provided for in **104.02**.

109.04 Methods of Payment for Additional or Altered Work

If the Department revises the Contract in accordance with **104.02**, the Department will adjust the Contract price using one of the following methods. The Department reserves the right to request detailed cost information for any request for a change to the Contract in accordance with **104.03** and may at any time direct the Contractor to perform all or part of the revised work by force account in accordance with **109.04.C**.

A. Contract Bid Item Prices

Before proceeding to another pricing method, the Engineer will attempt to price the revised work before the revised work is performed using Contract unit prices.

B. Negotiated Prices

If the Engineer and the Contractor cannot agree on a revised price in accordance with **109.04.A**, both shall attempt to negotiate new unit or lump sum prices before the revised work is performed. With negotiated prices, the Contractor must substantiate that the proposed prices are comparable to prices that would have resulted from a competitively bid contract. The basis for pricing may include:

1. Original Contract bid prices adjusted for increased or decreased material, equipment, or labor costs in accordance with **109.04.C**.

2. A bid item history exists for the revised work, and the proposed bid price is within 10% of the Regional 3-year historic cost for that item.

3. For work in unusual circumstances or with unusual site conditions, the average bid price for the three lowest bidders in the tabulation of bids for that work. If less than three bids are received, this option will not be used.

4. A cost analysis of the Contractor's detailed estimate of labor, equipment, materials, and markups in accordance with **109.04.C** to determine the reasonableness of costs.

When a Change Order is executed covering the revised work, the Department will make payment in accordance with the terms of the agreement. Profit and overhead shall not exceed 15% of the subtotal of materials, labor, and equipment. When a Change Order is initiated for subcontractor work, the administrative fee shall not exceed 5% of the subcontractor's total of materials, labor, equipment, profit, and overhead. If the Department negotiates with the Contractor, but does not agree on a price adjustment, the Engineer may direct the Contractor to perform all or part of the revised work by force account.

C. Force Account

When the Engineer directs the Contractor to perform work by force account, the Contractor shall be compensated in the manner described hereinafter. Submit a plan of operation for how force account work will be performed including a work schedule, estimated size of the work crew, an equipment list, and anticipated materials. The Department will

not allow the Contractor to perform force account work without this plan. The Department will make payments in the manner specified below, and this payment will be full compensation for the prosecution of the work performed on this basis.

1. Labor. For all labor and foremen in direct charge of the specific operations, the Department will pay the rate of wage or scale as previously shown on submitted certified payrolls, unless otherwise agreed upon in writing before the start of the force account work, for each and every hour that said labor and foremen are actually engaged in such work excluding general superintendence. The wages shall be comparable to wages or scale paid by the Contractor for work of a like nature on the Contract items. The Department will allow overtime only after authorized by the Engineer prior to the start of the force account work. If the labor or foremen are employed partly on specific force account work and partly on other work, the Department will prorate the amount of overtime to be reimbursed based on the number of hours worked on the specific force account work during the payroll period. The Department will not pay for commuting time to and from the Project under force account.

The Department will pay an additional amount for profit and overhead equal to 20% of the labor wages (excluding labor burden). When such amounts are required by collective bargaining agreement or other employment contract generally applicable to the classes of labor employed on the Work, the Department will pay the actual labor burden costs paid to, or on behalf of, such labor forces by reason of subsistence and travel allowances (i.e. per diem and lodging), health and welfare benefits, pension fund benefits, and other benefits. The Department will pay the Contractor's actual labor burden costs up to a maximum of 45% of all base (actual) wages paid to labor and foreman for the specific force account work. The Department will not pay labor burden additives for unauthorized overtime. The Contractor shall submit actual labor burden rates to the Engineer for approval before beginning force account work. If the Contractor cannot verify the actual labor burden rates, the Department will add to all base (actual) wages paid to labor and foreman for the specific force account work a flat 20% of the total of such base (actual) wage. These wages and percentage markups are full compensation for all costs associated with labor for the specific force account work.

2. **Bond, Insurance, and Tax.** The Department will pay the actual invoiced costs for property damage, liability, and workers' compensation insurance premiums, unemployment insurance contributions, and social security taxes on the force account work. Furnish satisfactory evidence of the rate or rates paid for such bond, insurance, and tax costs.

3. **Materials.** For materials accepted by the Engineer and used in the performance of the force account work, the Department will pay the actual cost of such materials delivered to the Project site, including transportation charges not included in unit prices (exclusive of machinery rentals as specified in **109.04.C.4**), to which 15% of the materials costs will be added for profit and overhead.

   Obtain competitive quotes from multiple materials suppliers and determine the most cost effective quote offering the best value to the Department. Provide statements supported by supplier invoices for all materials including transportation charges. However, if materials used on force account work are taken from the Contractor stock, then instead of invoices, furnish an affidavit certifying that the materials were taken from the Contractor's stock, that the quantity claimed was actually used, and that the material and transportation costs claimed represent the actual costs to the Contractor. The Contractor's authorized representative shall date and sign the statements.

4. **Equipment.** Equipment used for force account work shall be of the size, type, and number necessary to perform the required work in an economic and expeditious manner. Obtain equipment rental rates for any machinery or special equipment (other than small tools) and transportation costs to deliver equipment to the Project site. The rates shall be agreed upon and authorized by the Engineer before the start of force account work.

   Submit for approval a list of all Contractor-owned equipment or equipment rented from another contractor (i.e., an entity not in the commercial rental business), including the manufacturer, make, model, year of manufacture, type of fuel, and other necessary information to determine proper hourly payment rates.

   If a pick-up or light duty truck is necessary to perform force account work, the Department will pay at a rate consistent with the

rates in *The Rental Rate Blue Book for Construction Equipment* published by Equipment Watch for the actual hour of use.

Small tools, generally defined as hand-held with or without an engine and that are listed in *The Rental Rate Blue Book for Construction Equipment*, will be paid that rate for the hours used except that in no case shall payment exceed replacement cost of the item. The Engineer may approve specialty type small tools to be included in the equipment list.

Equipment rental rates will be determined by the current monthly rates established in *The Rental Rate Blue Book for Construction Equipment*. Reimbursement will not exceed the purchase price or salvage value, whichever is less. Maximum allowable equipment rates are determined as follows:

a. The hourly equipment rate equals the monthly rate, divided by 176. The hourly rate is then multiplied by adjustment factors for age and region.

b. The hourly operating cost shall not exceed the estimated operating cost in the Blue Book. The hourly operating cost shall include all costs and labor for routine maintenance and servicing, including but not limited to: fuel, lubrication, filters, blades, belts, pumps, lines, hoses, teeth, tires, tracks, and all other incidentals needed to operate and maintain the equipment. The Department will pay hourly rental rates for the actual time that the equipment is in operation. Do not use the weekly, daily, or hourly premium equipment rates shown in the Blue Book.

c. The hourly working rate equals the hourly equipment rate plus the hourly operating cost.

d. The idle or standby rate equals the hourly equipment rate multiplied by 50%.

e. The monthly rate includes the basic machine plus any attachments.

Idle or standby rates shall apply when equipment is not in operation and is approved by the Engineer to standby for later use

to complete the Work. In general, idle or standby rates shall apply when equipment is not in use, but will be needed again to complete the Work and the cost of moving the equipment will exceed the accumulated standby cost. If the idle standby cost should exceed the equipment moving cost to or from the work site, the Contractor will be entitled to the moving cost only. Idle or standby rates will be used under the following conditions:

a. The equipment is totally dedicated to the force account work and not used intermittently on other work.

b. Idle or standby cost will be considered only after equipment has been operated on force account work.

c. Idle or standby cost will be not be paid for more than 8 hours in a day or 40 hours in a week

d. The sum of idle or standby time and operating time shall not exceed 8 hours per day.

e. Idle or standby payment will not apply to days not normally considered to be work days such as holidays, weekends, or days of inclement weather when no other work is taking place.

The Department will not pay for idle or standby time when equipment is inoperable, for time spent repairing equipment, or for the time elapsed after the Engineer has advised the Contractor that the equipment is no longer needed. The Department will determine if it will be more cost effective to pay idle time on approved equipment on site or for multiple mobilizations.

If equipment is needed, which is not included in the Blue Book rental rates, the Department and Contractor will agree upon reasonable rental rates in writing before the equipment is used. The Contractor shall provide invoices to support equipment charges by individuals or firms other than the Contractor.

5. Rented or Leased Equipment. The Department will pay for equipment that is rented or leased from a commercial rental company at actual invoice price, provided the prices are fair and reasonable but not to exceed the monthly rate published in *The Rental Rate Blue Book for Construction Equipment*. The

Department will pay a markup of 15% for all rented/leased equipment for profit and overhead. The Contractor shall submit for approval the hourly operating cost for all rented/leased equipment if the rent/lease agreement does not include these expenses. The markup will not apply to hourly operating costs. Rented or leased equipment will not be subject to payment for idle time. The Contractor shall obtain competitive rates from multiple rental companies or equipment suppliers to determine the most cost effective rate offering the best value. The Department will determine if it will be more cost effective to leave the equipment on site and pay the invoice price or pay for multiple mobilizations.

6. **Transporting Equipment.** When it is necessary to transport approved equipment to the Project site, the Department will pay for these costs and the costs to return equipment to its original location, subject to the following conditions:

    a. The equipment is obtained from the nearest approved source;

    b. The return charges do not exceed the delivery charges;

    c. Haul rates do not exceed the established rates of licensed haulers; and

    d. Such charges are restricted to those units of equipment not already available and not on or near the Project.

    If the equipment is transported by the Contractor, the Department will pay by hourly rate, as calculated in accordance with **109.04.C.4**, for other equipment if not already covered in the rental rate. If the equipment is transported by common carrier, then payment will be the actual invoiced amount with no markup. If equipment is delivered to the Project site and used for other Contract items, then the Department will not pay for return costs.

7. **Subcontracting and Professional Services.** If a subcontractor at any tier performs force account work or associated professional services, the Department will pay for the actual reasonable cost of such subcontract work in accordance with **109.04.C** as if the subcontractor was the prime contractor. The prime contractor may apply an administrative fee of 5% for all approved force account work completed by subcontractors and for approved special

services associated with the force account work. No allowance will be made for subcontractors contracting lower tier subcontractors. Submit invoices for all subcontracted and professional services rendered (i.e. those not subject to Davis-Bacon or State prevailing wage rates).

8. **Miscellaneous Costs.** The Department will make no additional payment for general superintendence (Superintendent), time keepers, the use of small tools, or other costs for which no special allowance is provided. These costs are incidental to the force account work.

9. **Compensation.** The Contractor's representative and the Engineer will compare records of the cost of work done as ordered on a force account basis at the end of each day's work. The force account calculation is not intended to itemize incidental work. Compensation for incidental work is included in the allowable additives for labor and material costs.

10. **Statements.** The Department will not make payment for work performed on a force account basis until the Contractor has furnished the Engineer with duplicate certified and itemized statements of the cost of force account work detailed as follows:

    a. Name, classification, date, daily hours, total hours, rate, and extension for each laborer and foreman;

    b. Designation, dates, daily operating and standby hours, total hours, rental rate, and extension for each unit of machinery and equipment;

    c. Quantities of materials, prices, and extensions;

    d. Transportation of equipment and materials; and

    e. Cost of property damage, liability and workers' compensation insurance premiums, unemployment insurance contributions and social security tax.

    Provide support for all statements with receipted invoices for all materials used, including transportation charges. The Contractor's authorized representative shall date and sign the statements.

109.05 Eliminated or Altered Items

The Department reserves the right, in accordance with **104.02**, to eliminate or alter any portions of the Contract relating to the construction of any item or items or terminate the Contract for convenience as provided in **108.10.C**. The Department will pay a fair and reasonable amount covering all items of cost incurred prior to the date of cancellation, alteration, suspension, or termination of the Work as ordered by the Department.

A. Eliminated or Altered Items

The Department will purchase acceptable material ordered by the Contractor or delivered to the Project site prior to the date of elimination, alteration, or suspension of the item or items at actual cost plus delivery cost, including freight, unloading, and hauling unless otherwise provided. The purchased materials will become the property of the Department. No allowance will be made for anticipated profits. These provisions will likewise apply to elimination or alteration of any extra and force account work for which a Change Order has been executed.

The Department will not consider for purchase any materials used in construction items that are subject to variation in quantities, and that are ordered by the Contractor without the consultation or approval of the Engineer prior to the ordering of such materials. In addition, the Department will not consider for purchase materials ordered by the Contractor prior to the preconstruction meeting without the Engineer's written approval.

B. Termination for Convenience

If the Contract or any portion is terminated for convenience before completion of all items of Work in the Contract, the Department will pay for the actual number of Contract items completed at the Contract unit prices and mutually agreed as provided herein for items or work partially completed, or will pay on a force account basis, as determined by the Engineer. The Department may purchase acceptable material ordered by the Contractor or delivered to the Project site before the date of elimination or alteration, or suspension of the item or items at actual cost plus delivery cost, including freight, unloading, and hauling unless otherwise provided. The materials will become the property of the Department. The Department will not pay for loss of overhead or anticipated profits, including anticipated earnings on usage of owned

equipment, and impacts or other direct or indirect costs resulting from the termination.

The Department will pay for organization of the Work when not otherwise included in the Contract. The Department will pay for moving equipment to and from the Project site when the volume of work completed is too small to compensate the Contractor for these expenses under the Contract unit prices. If the Work is suspended in advance of the termination date, the Department also may consider reimbursing the Contractor for such cost items as mobilization, subcontractor costs not otherwise paid for, actual idle equipment costs for work stopped in advance of the termination date, and guaranteed payments for private land usage as part of the original Contract when not otherwise included in the Contract.

Termination of a contract or a portion thereof shall not relieve the Contractor of its responsibilities for the completed Work or Work to be completed that is not covered by the Notice of Termination, nor shall it relieve the Surety of its obligation for and concerning any just claims arising out of the Work performed or to be performed. Submit a claim request for additional costs, not covered in this section or elsewhere in the Contract, within sixty (60) calendar days of the effective termination date in accordance with **105.16.**

109.06 Compensable Delay Costs

For a compensable delay determined in accordance with **108.07**, the Department will pay time-related delay costs for cumulative delays that exceed the adjusted Contract completion date. Seasonal limitations (i.e., a winter shutdown period) will not be considered in the calculation of time-related delay costs. The Department will not pay for delay costs until the Contractor submits an itemized statement of these costs in accordance with **109.04.C**. The following cost categories may apply:

A. Escalated Labor

To receive compensation for escalated labor, demonstrate that the delay forced the Work to be performed during a period when labor costs were higher than planned at the time of bid. Provide adequate support documentation for the escalated labor costs, allowances, and benefits as specified in **109.04.C**.

B. Materials Escalation or Material Storage

The Department will pay the Contractor for increased material costs or material storage costs only if the delay resulted in material cost escalation or extended storage costs. Fuel and asphalt costs are indexed and therefore excluded from escalation. Obtain the Engineer's approval before storing materials due to a delay.

C. Idle Equipment or Equipment Demobilization

The Contractor will provide costs for demobilization of equipment, and the Department will decide whether to pay for demobilization or idle equipment costs for a compensable delay. If not otherwise compensated under force account, the Department will pay the Contractor in accordance with **109.04.C.4** for idle equipment, other than small tools, that cannot be used for active work and must remain on the Project associated with the delay. Alternatively, the Department will pay for the Contractor's transportation costs to remove and return equipment not required on the Project during delays. No other equipment costs are recoverable as a result of delay.

D. Extended Field Overhead

Project specific field overhead costs shall include only the cost of supervision, field office facilities and supplies, and maintenance of field operations, traffic control, and erosion control. General supervision costs include, but are not limited to, field supervisors, assistants, watchmen, and clerical and other field support staff. For salaried personnel, calculate the daily wage rate by dividing the weekly salary by 5 days per week. Field office facility and supply costs include, but are not limited to, field office trailers, tool trailers, office equipment rental, temporary toilets, and other incidental facilities and supplies. Maintenance of field operations include, but are not limited to, telephone, electric, water, and other similar expenses.

Compute these costs on a calendar day basis using actual costs incurred due to the delay to provide supervision and field office facilities, and to maintain field operations. Alternatively, the Department may at its discretion compute a daily field overhead rate as a percentage of the original Contract amount divided by the Contract duration.

E. Home Office Overhead and Profit

The Department will pay home office overhead and profit at a rate of 15% for items A through D above that are approved by the Engineer.

F. Insurance and Bond Costs and Additional taxes

The Department will pay for documented additional or escalated premiums on bonds and insurance, and additional taxes incurred during the delay.

109.07 Non-Recoverable Costs

The Department will not provide additional compensation for the following items and the Contractor agrees that it shall not claim for the following items of cost:

1. Home office overhead and profit in excess of that provided above;

2. Those items in **109.06** not eligible for reimbursement;

3. Loss of anticipated profits;

4. Labor inefficiencies and loss of productivity;

5. Attorney fees, claim preparation expenses, and cost of litigation; and

6. Consequential damages, including but not limited to, interest of monies in dispute, loss of bonding capacity, any indirect costs or expenses, interest on investment or any resultant insolvency

109.08 Partial Payment

The Department will make monthly payments to the Contractor for work performed and materials placed under the Contract, and for materials delivered and stored in accordance with **109.09**. The monthly payment is an estimate, and all partial payments are subject to correction in the Final Payment. The Department will not make partial payments of less than $1,000.

The Department will not withhold retainage from the Contractor.

After the first partial payment, the Department reserves the right to withhold subsequent partial payments until the Contractor satisfies the Department that the work for which payment is made was performed in accordance with the Contract, and each subcontractor or supplier has been paid for labor, material, and equipment costs on a current basis, or there exists a valid basis for withholding payment to subcontractors or suppliers.

Partial payment for work or materials does not constitute acceptance or approval of defective work or material. Should the Department discover defective construction or material, or a reasonable doubt exists as to the satisfactory quality of any part of the construction completed prior to final acceptance and payment, the Department reserves the right to deduct from current or future pay estimates an amount sufficient to ensure the repair or replacement of such work by the Contractor or by others as may prove necessary.

109.09 Payment for Stockpiled Materials

When requested in writing by the Contractor and approved by the Engineer, the Department may make partial payment of non-perishable materials that will be permanently incorporated into the Project. Stockpile these materials in an approved manner on or near the Project site or in special cases at an offsite location because of fabrication. Limit these off-site locations to special cases where the material cannot be readily stockpiled at the Project site such as steel structure components and prefabricated bridge components. Clearly mark material stored at an off-site location with the Project information. Provide a map noting the location. Store the stockpiled material in an approved manner so that the quality of the material is not compromised. The Department will not make payment prior to inspection and documentation by the Engineer. Clearly identify material, whether stored on-site or off-site, in order to reference the quantity and assigned Project.

The Department may only consider partial payment for an invoice or accumulation of invoices totaling $5,000 for each eligible pay item. Individual invoices shall not total less than $2,500. Invoices may include tax and freight. Partial payment shall not exceed 100% of the invoice amount or 75% of the Contract unit price, whichever is less.

Materials that may be included in partial payments are: aggregates (stored at the Project, not at a quarry), reinforcing steel, bridge piling, structural steel (fabricated units or steel delivered to fabricator if designated for particular project), precast concrete structures, traffic signal equipment,

electrical equipment, fencing materials, sign materials, guardrail, and others as approved by the Engineer.

Materials that may not be included in partial payments are: living or perishable plant materials, seed, fuel, used materials, form lumber, falsework, temporary erosion items, and other temporary items that will not become part of the completed Work.

When requesting payment for stockpiled materials, provide a written request to the Engineer that contains the following information:

1. Contract and Project numbers,

2. Item number and description as stated in the Contract proposal,

3. Quantity and unit of measure,

4. Conversion factor, if applicable,

5. Written statement of assurance that material will be used on the specific project,

6. Written consent of prime contractor's surety,

7. Material certifications/test reports for the material, and

8. Copy of certified paid invoice (in order to certify, a representative of the supplier must mark the amount of the invoice as actually paid, and shall sign and date it).

If the certified paid invoice is unavailable, the Engineer may conditionally approve a stockpile payment with receipt of the Surety's consent and a copy of the unpaid invoice. However, the Contractor shall submit the certified paid invoice within thirty (30) calendar days following the date of the progress payment for which the stockpiled material was paid. If the certified paid invoice is not submitted, the Department will deduct the stockpile payment from the next progress payment. Additional requests for stockpile payment of that item must be accompanied by a certified paid invoice, or the request for stockpile payment will not be paid.

Stockpile payments shall not exceed the Contract amount, unless the Contract amount is increased by an approved Change Order. The

Department will not make payment for items that will be incorporated permanently into the Project within thirty (30) calendar days from request of stockpile payment.

Protect the stockpile materials from the elements and against loss or damage by any cause. If any stockpiled materials are lost, stolen, impaired or damaged after partial payment has been made, the Department will deduct the monetary value of the lost, stolen, impaired or damaged material from the next estimate, and will not make further payment until such material has been satisfactorily replaced in accordance with the Contract.

109.10 Final Payment

After inspecting and accepting the Project in accordance with **105.15**, the Engineer will prepare a final estimate for the Contract that reflects the following:

1. All accepted final contract quantities,
2. All previous partial payments, and
3. Any increases or deductions made in accordance with the Contract.

The Engineer will submit the final estimate to the Contractor for review and acceptance. Within thirty (30) calendar days of receipt of this estimate, notify the Engineer of whether the final quantities are acceptable or not acceptable. If not acceptable, provide an item-by-item list with reasons for disagreement with the final estimate. After considering the reasons for disagreement, the Engineer may or may not revise the final estimate based on its review of the Contractor's justification.

When the Project has been accepted, the Department will advertise a thirty (30) calendar day notice in accordance with TCA §54-5-122, in a newspaper published in the county where the Work is done, if there is a newspaper published there, and if not, in a newspaper in an adjoining county. The notice will state that settlement is about to be made and all claimants must file notice of their claims with the Department in accordance with TCA §54-5-122. The period for filing a notice of claim shall not be less than thirty (30) calendar days after the last published notice. No notice of claim is valid unless it is certified and filed after the publication of the first notice.

The Contractor shall furnish evidence to satisfy the Department that all the materials used have been paid for, its subcontractors or agents have been

fully paid, and all of the Contractor's laborers and other employees have been fully paid.

If no claims are filed within the thirty (30) calendar day period, and the Contractor has provided the required evidence of payment and releases, the Department will make full settlement and final payment to the Contractor.

The Engineer will not require the Contractor to maintain the Project or perform any further construction after final acceptance in writing by the Engineer, except as otherwise provided.

109.11 Payment of Costs Owed to the Department

Notwithstanding anything to the contrary in the Contract, the Contractor shall be liable to the Department for any or all of the following: fraud or such gross mistakes as may amount to fraud, the Department's rights under any warranty or guarantee, or latent defects in the Work.

The Department reserves the right to set off the following against any contractual amount otherwise due the Contractor or its Sureties, or both:

1. All costs that the Department has incurred due to Contractor or Surety noncompliance with this Contract, and

2. Any other amounts that the Contractor or its Sureties, or both, owe the Department.

PART 2 – EARTHWORK

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DESCRIPTION

201.01 Description

This work consists of clearing, grubbing, removing, and disposing of all vegetation and debris within the designated limits, except such objects that are to remain or are to be removed according to other items of work. This work also includes preserving from injury or defacement all vegetation and objects designated to remain.

201.02 Reserved

CONSTRUCTION REQUIREMENTS

201.03 Clearing and Grubbing

A. General

The Engineer, or Contractor when required, will establish right-of-way and construction lines. The Engineer will designate all trees, shrubs, plants, and other objects to remain.

Avoid clearing and grubbing operations in areas designated to remain undisturbed in the Project's Stormwater Pollution Prevention Plan and applicable environmental permits.

For clearing and grubbing activities associated with Contractor-supplied borrow pits and waste areas, ensure that the areas

have been approved in advance by the Engineer, the Environmental Coordinator, and the Environmental Division. Operate and maintain such areas according to the manual *Procedures for Providing Offsite Waste and Borrow on TDOT Construction Projects*.

Perform clearing and grubbing in advance of excavation and embankment operations.

B. Preparation

Before beginning construction activities, clearly mark the limits of disturbance (clearing limits) with stakes or other acceptable visible markers. Also mark all environmentally sensitive areas, such as streams, wetlands, buffers, and ARAP boundaries, included in the Project limits with markers that are readily visible to project personnel, including equipment operators.

C. Clearing and Grubbing Activities

1. **Within the Right-of-Way.** Clear all dead trees, stumps, brush, projecting roots, hedge, weeds, pole stubs, logs, and other objectionable material from the right-of-way necessary for construction, as directed by the Engineer.

   Clear all hedges, weeds, pole stubs, logs, and other objectionable material, that are located inside the right-of-way but outside the construction lines, flush to the ground surface.

2. **Within 5 Feet of the Construction Lines.** Completely grub all trees, stumps, roots, pole stubs, brush, hedge, and other protruding obstructions within the area bounded by lines 5 feet outside the construction lines. The Contractor may leave in place sound, undisturbed stumps and roots that will be a minimum of 5 feet below subgrade or slope of embankment under the following conditions:

   a. Undercutting or other corrective measures, or topsoil stripping, is not stipulated in the Plans or directed by the Engineer; and

   b. Stumps do not extend more than 6 inches above the ground surface.

3. **More than 5 Feet Outside the Construction Lines.** Do not disturb, and protect from damage and injury, living trees that have not been marked for removal by the Engineer and that are located more than 5 feet outside the construction lines of the road. Treat cut or scarred surfaces of trees or shrubs with a paint prepared especially for tree surgery.

   Cut off trees marked for removal by the Engineer, to within 6 inches of the ground surface. Trim all stumps to within 6 inches of the ground surface.

4. **Swampy Areas.** When embankments are to be constructed in swampy areas, and undercutting or other corrective measures are not shown on the Plans or directed by the Engineer, the Contractor may, with the Engineer's approval, cut off undisturbed trees and stumps at not more than 6 inches above the ground surface or low water level and leave the stump and root mass in place.

5. **Borrow Pit Areas.** In areas approved as borrow pits by the Engineer, clear and grub all trees, stumps, brush, and heavy vegetation.

   In areas designated for obtaining construction material other than borrow, clear and grub trees, stumps, brush, and vegetation, and strip overburden lying above the material to be obtained.

   Complete this work prior to removing borrow or construction materials. Operate and maintain all offsite borrow areas according to the manual *Procedures for Providing Offsite Waste and Borrow on TDOT Construction Projects*.

6. **Drainage Areas and Structures.** Clear slopes of cuts, embankments, ditches, channels, waterways, and all structures, both old and new, of all brush, hedges, weeds, heavy vegetation, and other objectionable material. Maintain such areas in a neat and satisfactory condition until the Project is accepted.

   Clear areas that are within the limits of drainage structures of all objectionable material to within 3 inches of the ground surface. Such areas shall extend the full length of the structures, as measured along the center-line of the highway, and to the right-of-way lines along lines parallel to the centerline of the inlet and outlet channel or drainage of the structure. These areas shall also

include the entire area of all easements obtained for drainage purposes.

7. **Removing Branches.** Remove, as directed by the Engineer, low hanging, unsound, or unsightly branches on trees or shrubs designated to remain. Trim tree branches that extend over the roadbed to provide a clear height of 20 feet above the roadbed surface. Perform trimming operations using skilled workmen and good tree surgery practices.

D. Backfilling

Within the areas where embankments are to be constructed, backfill all depressions resulting from grubbing operations with suitable excavation material, and compact as specified in **205** to the natural ground elevation before starting embankment construction.

Backfill, with suitable material, all depressions in excavation areas that lie below the finished subgrade elevation due to grubbing operations, and compact to the finished subgrade elevation as specified in **205** during the excavation operations.

Complete backfilling a satisfactory distance ahead of embankment construction operations.

201.04 Disposal of Debris

Properly dispose of wood debris that is chipped onsite so that does not become part of embankment.

If burning perishable material, follow applicable laws and ordinances. Ensure burning operations proceed under the constant care of competent watchmen, at times and in a manner that will not harm the surrounding vegetation, adjacent property, or anything designated to remain within the right-of-way.

If the construction is through land subject to scour, the Engineer may direct the Contractor to dispose of stumps, logs, brush, and similar material in the scoured ditches within the right-of-way, and to cover the material so deposited with suitable excavation or borrow material. If the Contractor obtains permission to dispose of such material in scoured ditches on private property that is within view of the roadway, the Contractor shall thoroughly

cover the material so deposited with suitable material at no cost to the Department.

All merchantable timber in the clearing area that has not been removed from the right-of-way before the start of construction shall become the property of the Contractor unless otherwise specified.

COMPENSATION

201.05 Method of Measurement

If the Contract contains an item for Clearing and Grubbing on a lump sum basis, the Department will not measure the area cleared and grubbed.

In cases where changes in the Contract documents affect the right-of-way area or when additional Clearing and Grubbing is required in conjunction with Road and Drainage Excavation (Additional Material) under **203**, the Department will make a proportionate adjustment for the increased or decreased area; however, if the bid schedule includes the item for Adjusted Clearing and Grubbing, then the Department will measure and pay for these area adjustments by the acre.

Unless otherwise shown on the Plans, no separate measurement or payment will be made for the items of work defined under Clearing and Grubbing.

For Contractor-supplied borrow pits, the Contractor shall include clearing and grubbing costs in the unit price bid for Borrow Excavation under **203**. For Department-obtained designated borrow pit areas, the Department will measure and pay for clearing and grubbing by the acre, provided the item for Clearing and Grubbing (Borrow Pits) is in the Contract. If the item for Clearing and Grubbing (Borrow Pits) is not in the Contract, the Contractor shall include the costs of clearing and grubbing such designated borrow pit areas in the unit price bid for Borrow Excavation.

If the Contract does not contain an item for Clearing and Grubbing, the Department will consider all Clearing and Grubbing required within the construction limits as incidental to other items of work.

201.06 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Clearing and Grubbing	Lump Sum
Clearing and Grubbing (Borrow Pits)	Acre
Adjusted Clearing and Grubbing	Acre

Such payment is full compensation for providing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 202 – REMOVAL OF STRUCTURES AND OBSTRUCTIONS

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DESCRIPTION

202.01 Description

This work consists of removing, entirely or partially, and disposing of all buildings, fences, structures, old pavements, abandoned pipe lines, and other obstructions not designated or permitted to remain, except for obstructions to be removed and disposed of under other contract items. The work also includes backfilling the resulting trenches, holes, and pits, and salvaging designated materials.

If the Contract does not include pay items for Removal of Structures and Obstructions, include such work in the prices bid for other items of construction.

202.02 Reserved

CONSTRUCTION REQUIREMENTS

202.03 General

Raze, remove, and dispose of all buildings and foundations, structures, fences, and other obstructions as shown on the Plans. Do not remove utilities and obstructions for which other provisions have been made.

Remove material designated for salvage in readily transportable pieces, and store the removed pieces at specified locations within the Project limits. Replace with new material, at no additional cost to the Department, those materials designated for salvage that are damaged during removal, transport, or storage operations. Take ownership of material not designated for the Department's use, and dispose of such material beyond view from the Project limits. If disposing of material on private property, obtain written permission from the property owner and adhere to the manual *Procedures for Providing Offsite Waste and Borrow on TDOT Construction Projects*.

The Department reserves the right to dispose of buildings on any tract before they are torn down or removed by the Contractor. If structures designated for removal by the Contractor contain friable asbestos, conduct demolition activities according to TDEC policy and regulations, including providing prior notification to TDEC of all pending demolitions. The Department will remove friable asbestos from other structures to be demolished either prior to, or concurrently with, the Work. The Department's removal of friable asbestos may or may not include complete demolition of the structure. Remove structures, or portions of a structure, remaining after the Department's removal of asbestos under the appropriate item or in accordance with **202.01**, as applicable.

Buildings and other structures that the Plans show as being removed or disposed of by other agencies will not be held as a charge or responsibility of the Contractor, except that the Contractor waives any and all claims for interference, delay, or damage due to their removal or non-removal.

Remove foundations of buildings and other structures to a depth of not less than 1 foot below natural ground, except that within construction limits, remove to a depth of not less than 2 feet below subgrade elevation. Break up basement floors to prevent water retention. Fill basements or cavities

left by structure removal to the level of the surrounding ground or to subgrade elevation within the prism of construction. Compact the material placed in these cavities as specified in **205**.

202.04 Removal of Bridges, Culverts, and Other Drainage Structures

Do not remove structures in use by traffic until after making arrangements to accommodate traffic.

Remove all bridges, culverts, and drainage structures from streams according to the terms and conditions specified in the applicable environmental permits, including the TN Construction General Permit. Use highly visible markers to clearly mark permit boundaries and disturbed area limits.

Unless otherwise specified or directed, remove portions of bridge substructures that are located outside a stream to 1 foot below the adjacent ground level or natural stream bottom, or the lowest scour elevation shown on the Plans. For those portions that are located in a stream or wetland, adhere to the permit form of the applicable State and Federal agencies approving the location and plans and authorizing the construction of the bridge. Remove, as necessary, those portions of existing structures that lie entirely or partially within the limits of a new structure to accommodate the construction of the proposed structure.

Without causing unnecessary damage, dismantle bridges designated for salvage, and store such material as specified in **202.03**.

Remove bridge decks according to the following:

1. Where bridge decks are to be entirely removed, but the girders are to remain in service:

    a. The Contractor may apply transverse saw cuts to help remove the concrete deck, but the depth of the cut may not exceed:

        (1) 3 inches for decks supported by steel beams or girders;

        (2) 3 inches for decks supported by prestressed concrete beams; and

(3) 1 inch for decks of cast-in-place hollow box or t-beam bridges.

b. Use pneumatically or electrically operated chipping hammers, not exceeding 60 pounds in weight, to remove the remainder of the slab depth under the cuts.

c. Longitudinal saw cuts may be full depth, but no closer than the following:

(1) For decks supported by steel beams or girders, within 1 inch of the widest top flanges;

(2) For decks supported by prestressed beams, within 1 inch of the top flange; and

(3) For decks of hollow boxes or t-beam bridges, within 1 inch of the web, unless otherwise shown on the Plans.

2. To remove slab overhangs, the Contractor may use concrete saws to remove the top 1 inch of the slab and pneumatically or electrically operated chipping hammers, not exceeding 60 pounds in weight, to remove the remainder of the concrete. Do not damage transverse slab reinforcing bars.

3. When removing bridge decks as part of a complete bridge demolition, the Contractor may use concrete saws to remove the deck, but the depth of the cuts may not exceed the following:

a. For decks supported by steel beams or girders, the plan depth of slab minus 1 inch.

b. For decks of hollow box or t-beam bridges, if not otherwise shown on the Plans, the Contractor shall submit a plan to the Engineer for approval.

Do not use hoe rams, pneumatic shears, pavement breakers, or other heavy equipment to remove slabs where girders or adjacent slab portions are to remain.

Complete blasting or other operations necessary to remove an existing structure or obstruction without damaging new construction. Complete

such operations prior to placing the new work, or take adequate precautions to prevent such damage.

202.05 Removal of Pipe

Remove, and store when necessary, pipe designated for salvage so that no loss or damage occurs. Replace, at no cost to the Department, sections damaged by negligence or by the use of improper methods.

202.06 Removal of Pavement, Sidewalks, and Curbs Constructed of Portland Cement Concrete

As directed, dispose of pavement, base course, sidewalks, curbs, gutters, and similar features constructed of Portland cement concrete designated for removal. If the Plans do not to identify the existence of concrete pavement under asphaltic pavement, do not interpret this as meaning that no concrete is present. Remove and dispose of concrete pavement, parking strip, and base, all with or without bituminous overlay, concrete curb and gutter, sidewalk, driveways, and similar features as follows or as directed:

1. If the items are no more than 2 feet below subgrade elevation, remove and dispose of the items according to this Section **202**.

2. If the items are more than 2 feet below subgrade elevation, break them into sections no greater than 2 feet in maximum dimension and leave in place, unless doing so will interfere with succeeding items of construction. Include the cost of this work in the unit price bid for other items of construction.

3. If the items are above subgrade elevation, include their removal and disposal with the work performed under **203.**

4. When specified, remove and stockpile ballast, gravel, bituminous pavement, or other pavement materials in accordance with **202.03**; otherwise, dispose of such materials as directed.

202.07 Removal of Underground Storage Tanks

A Petroleum Underground Storage Tank refers to any one or combination of tanks including underground piping, which is used or has been used to contain petroleum substances and the volume of which is 10% or more beneath the surface of the ground.

The Department will remove and dispose of Petroleum Underground Storage Tanks or Tank Systems through its Environmental Consultant. This work will include removal and disposal of piping, pumps, and other tank fixtures, the investigation and testing of the tank(s) for leakage, and backfilling the resulting holes or trenches as shown on the Plans or as approved by the Engineer. The Department's Environmental Consultant will perform this work according to the Tennessee Petroleum Underground Storage Tank Act, TDEC policies and regulations, the United States Environmental Protection Agency, and local ordinances or statutes governing removal of Underground Storage Tanks.

If the Contract includes an item for Removal and Disposal of Underground Tanks, before work begins, submit an application for closure of each Petroleum Underground Storage Tank or Tank System to the TDEC, Division of Underground Storage Tanks. In addition, the Contractor shall:

1. Provide the Engineer with copies of the application for closure, the TDEC's approval of that application, laboratory test reports, closure notification form, and all pertinent correspondence.

2. Engage a laboratory approved by the TDEC to perform all required sampling and testing for leakage and contamination before and after removal of the tank(s). Upon receipt of written approval from the TDEC, remove the tank(s) according to TDEC regulations. If soil testing either before or after tank removal reveals soil contamination, remove and dispose of the contaminated soil according to TDEC regulations.

3. After removal, take ownership of the tank(s) and tank fixtures unless otherwise shown on the Plans. Ownership of the tank(s) shall not relieve the Contractor of the responsibility of labeling, transporting, and disposing of the tank(s) according to TDEC regulations.

4. After removing the tank(s) and contaminated soil, backfill the hole or trench as necessary with material specified on the Plans or approved by the Engineer.

202.08 Water Well Abandonment

Locate and seal abandoned water wells, and remove and dispose of pumps, pipe, and other related items not provided for elsewhere in the Contract. Perform all work according to applicable TDEC regulations.

Seal abandoned wells as follows:

A. Wells with a Diameter of 1 Foot or Less

Retain a licensed driller or pump installer to remove all pumps and related plumbing. Clear the bore hole of all other obstructions. A licensed well driller shall clean the bore hole by drilling, blowing, or bailing as applicable. To disinfect the well, add laundry bleach to the water in the well to equal 1 quart of bleach for each 100 gallons of water. Obtain the number of gallons of water in the well as follows:

$$V = [D_{well} - D_{swl}] \text{ x } 0.0408(Dia^2)$$

Where:

V	=	volume of water in the well in gallons
D_{well}	=	total depth of the well in feet
D_{swl}	=	depth to static water level in feet
Dia	=	diameter of the well in inches

After disinfecting the well, the licensed well driller shall fill the well using flowable fill. Use bentonite or other approved colloidal reagent as an additive in an amount equal to 1.5% by volume of the cement.

The flowable fill material shall extend from the bottom of the well to within 5 feet of the final surface where the well is in a roadway cut, or to within 5 feet of the existing ground surface where the well is located under roadway embankment or where the well is outside of the construction limits. Pipe the flowable fill directly to the point of application by a tremie or dump bailer to avoid segregation or dilution. Cut off the well casing flush with the top of the flowable fill material.

B. Wells with Diameter Greater than 1 Foot

Remove all pumps and related plumbing, and clear the well of all other obstructions as described in **202.08.A**. Disinfect the water in the well by adding 1 quart of bleach for each 100 gallons of water. Compute the amount of bleach to be used as described in **202.08.A**.

Fill the bottom 5 feet of the well or a depth equal to the depth of the water, whichever is greater, with flowable fill as specified in **202.08.A**. Fill the remainder of the well with compacted soil. Remove projecting

well casings or walls or cut off 5 feet below the existing or proposed ground surface, as applicable.

If flowable fill loss is excessive due to crevices in the borehole wall, use Mineral Aggregate, Type A Base, Grading D, meeting **903.05**, to seal the crevices. After sealing the crevices, resume filling with flowable fill.

Immediately after sealing the wells, provide an affidavit to the Tennessee Water Supply Division stating the name of the licensed contractor(s) who performed the cleaning and sealing of the wells, the project number, location of the wells, type and sequence of material used, volume of material used, and date completed.

COMPENSATION

202.09 Method of Measurement

If the Contract specifies that Removal of Structures and Obstructions is on a lump sum basis, the work will include all structures and obstructions encountered within the right-of-way, except for structures and obstructions specified for removal on a unit basis.

If the Contract specifies removal of specific items on a unit basis, the Department will measure the quantity of each item by the unit stipulated in the Contract.

202.10 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Removal of Structures and Obstructions	Lump Sum, or Each
Removal of Pipe (Size, Sta)	Linear Feet
Removal of Rigid Pavements, Sidewalks, etc.	Square Yard
Removal of Undergrounds Tanks (Tract No._____)	Lump Sum
Removal of Buildings (Tract No._____)	Lump Sum
Water Well Abandonment	Lump Sum

Payment for Removal of Underground Tanks (Tract No._____) includes locating, drilling, testing, removing, and disposing of Underground Storage

Tanks, piping, pumps, and other tank fixtures, any portion of which is on the designated tract, and hauling, placing, and compacting backfill where required.

If soil testing reveals contamination, the Department will pay for the removal and disposal of contaminated soil under the item for Road and Drainage Excavation (Unclassified) in accordance with **203**, provided the volume is 500 cubic yards or less. However, the Department may consider the removal, disposal, and replacement of contaminated soil in excess of 500 cubic yards as Extra Work under **104.02.D** and will then pay for such work in accordance with **109.04**.

Payment for Water Well Abandonment includes all labor, equipment, materials, including flowable fill, and incidentals necessary to complete the work.

Payment for removing specific obstruction items, including Removal of Pipe and Removal of Rigid Pavements, Sidewalks, etc., includes the removal of such items; excavation and subsequent backfill incidental to their removal; salvage of materials removed, their custody, preservation, and storage within the right-of-way; and disposal.

The Department will only make payment when payment for all or any part thereof is provided for in a pay item.

SECTION 203 – EXCAVATION AND UNDERCUTTING

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DESCRIPTION

203.01 Description

This work consists of excavating and grading the roadway (including the removal of slides), borrow pits, waterways, and ditches (including structure inlet and outlet ditches, channels, waterways, and similar features, even if they extend beyond the highway limits); excavating for intersections, approaches, and benches under the side-hill embankments; excavating unsuitable material from roadbed and beneath embankment areas; excavating selected material found in the roadway that is required for specific use in the construction; the construction and removal of detours authorized by the Engineer or otherwise shown on the Plans; trimming and shaping of all slopes; and disposing of all excavated material.

The work also includes all embankment construction as specified in **205**, shoulder and ditch construction as specified in **208**, and if the Contract includes construction of pavement or other surfacing, Subgrade Construction and Preparation as specified in **207**.

203.02 Classification

The Department will classify excavation as follows:

A. Road and Drainage Excavation (Unclassified)

The Department will consider all excavation performed under this item, including Portland cement concrete located above subgrade elevation, other than Borrow Excavation, Channel Excavation, and Undercutting, as unclassified excavation regardless of the nature of the material excavated.

B. Borrow Excavation

Borrow Excavation consists of material required for the construction of embankments or other portions of the work. Obtain borrow from approved sources outside the right-of way according to the manual *Procedures for Providing Offsite Waste and Borrow on TDOT Construction Projects*, unless otherwise shown on the Plans.

The Contractor may use excavated materials, other than Borrow Excavation (Unclassified), on the Project as specified in **104.09** provided it meets the specifications of the designated borrow material. However, if the flattening of certain cut slopes on projects graded under previous contracts is desirable and approved in writing by the Engineer, the Contractor may use this material for borrow if the material is satisfactory and in accordance with plans approved by the Engineer, and if the requirements of **203.04.E** regarding borrow areas are met.

Do not obtain borrow material from wetland areas, unless otherwise shown on the Plans and approved by applicable environmental permits.

The Department will classify borrow as:

1. **Borrow Excavation (Solid Rock)**, which consists of removing and placing non-degradable rock that cannot be economically excavated by the proper use of a power shovel or without the use of explosives.

2. **Borrow Excavation (Unclassified)**, which consists of removing and placing all approved material included under the classification of Borrow Excavation (Solid Rock) and all other approved material.

3. **Borrow Excavation (Graded Solid Rock)**, which consists of removing and placing sound, non-degradable rock having the following characteristics:

a. Maximum particle size of 3 feet in any direction.

b. Particle size distribution in which at least 50% of the rock is uniformly distributed between 1 foot and 3 feet in diameter, and no more than 10% is less than 2 inches in diameter.

c. Roughly equi-dimensional in shape.

d. No thin, slabby material.

Process the material using an acceptable method that produces the required gradation. When the material is subjected to five alternations of the sodium sulfate soundness test according to AASHTO T 104, the weighted percentage of loss shall be not more than 12. Obtain the Engineer's approval before using the material.

4. **Borrow Excavation (Select Material)**, which is used for special construction purposes and meets the requirements set forth in the Contract or shown on the Plans.

Borrow material other than solid rock, graded solid rock, or select materials shall be AASHTO M 145, classification A-6 or better if reasonably available. If classification A-6 is not reasonably available, the borrow shall be no worse than the predominant soil type in the roadway excavation based on AASHTO classification.

Do not use material obtained from an approved borrow source off the right-of-way to produce processed aggregate as described in **903**. Do not use material excavated from an offsite borrow source in base or other paving courses above the elevation of the subgrade.

Unless otherwise designated in the Contract, arrange for obtaining borrow material according to the manual *Procedures for Providing Offsite Waste and Borrow on TDOT Construction Projects*.

C. Channel Excavation (Unclassified)

This item consists of removing and disposing of all material excavated in widening, deepening, and straightening existing channels or constructing new ones, which have a bottom width of more than 14 feet as shown on the Plans. Perform similar excavation activities for

channels with a bottom width of 14 feet or less, as shown on the Plans, under the Road and Drainage Excavation (Unclassified) item. Construct channel excavation that includes an existing stream or a proposed stream relocation in accordance with the applicable environmental permits.

D. Undercutting

This item consists of removing and disposing of unsatisfactory materials below grade in cut sections and from areas upon which embankments are to be placed, and may also include excavating material below the foundation elevation for pipe, box culverts, and box bridges as provided for in **204.12**. Undercutting does not include the stripping, stockpiling, and placing of topsoil, as specified in **203.06**, nor does it include step-benching in the preparation of embankment areas on hillsides, as provided for under **205.03**.

203.03 Reserved

CONSTRUCTION REQUIREMENTS

203.04 General

Perform the required Clearing and Grubbing, Removal of Structures and Obstructions, and placement of Erosion Control Devices as specified in **201**, **202**, and **209**, respectively, before starting excavation, grading, and embankment operations.

Address both natural and created steep slope areas as required in the TN Construction General Permit. Maintain and stabilize steep slopes according to the TN Construction General Permit and all applicable environmental permits.

Remove excavation materials so that the slopes may be neatly trimmed to the lines given. The Engineer may change the slopes shown on the original cross-sections, depress raised medians or islands, raise depressed medians or islands, or daylight cuts to increase or decrease the quantity of Road and Drainage Excavation (Unclassified) if the material can be excavated without blasting and these changes are set in the slope stakes before excavation of the affected slopes, medians, or islands begins.

Use all suitable materials removed from the excavation areas to construct embankments, intersecting road approaches, and in such other places as directed by the Engineer. Construct embankment as specified in **205**.

Remove all loose rock on cut slopes immediately.

Do not waste, deposit or dispose of excavated material outside the construction lines without the Engineer's approval. Ensure that all excavation material wasted, deposited, or disposed of outside the construction lines is in accordance with the manual *Procedures for Providing Offsite Waste and Borrow on TDOT Construction Projects*.

Temporarily discontinue excavating operations upon encountering remains of prehistoric archeological sites or artifacts of historical or archaeological significance. The Engineer will contact archaeological authorities to determine the disposition thereof.

Scarify, obliterate, and apply topsoil and seed to all existing roads within the right-of-way, and not in the graded area, which are to be abandoned. Obliteration of old roadways shall include all grading operations necessary to incorporate the old roadway into the new roadway and surroundings to provide a natural terrain appearance from the new roadway.

A. Additional Material

If more material is required to complete the embankments after all cuts have been brought to grade and all Road and Drainage Excavation (Unclassified) has been removed from within the balance, obtain additional materials from within the right-of-way by flattening, widening, or daylighting cut slopes, or by depressing raised medians or islands at locations designated and as directed by the Engineer, provided:

1. The cost of this material is more economical than borrow excavation.

2. The material is available within the adjusted balance where the shortage exists or the material may be hauled outside the limits of adjusted balance if the cost of the material is more economical than borrow after considering the additional cost of overhaul.

3. The material can be excavated without blasting.

4. There is a minimum of 20 feet between the top of the existing slope and the top of the new slope and a minimum of 5 feet between the top of the new slope and right-of-way line or Control Access fence. The 20-foot minimum will not apply when the existing slope is 4:1 or flatter or to overlapping or near overlapping slopes in medians or between parallel roads or ramps. The Engineer may reduce the 20-foot minimum at the Contractor's written request.

B. Rock Cuts

Construct roadbed through rock cuts to the grading line shown on the Plans, with an allowable working tolerance of plus 1 inch to minus 3 inches. Bring portions of the roadway that are less than 3 inches below grade up to grade with spalls or other suitable granular material that is available from the excavation within the balance. If such excavation is not available, the Engineer may direct the Contractor to use approved base material for capping.

If the roadbed is excavated in excess of 3 inches below the grading line shown on the Plans, provide and place, at no additional cost to the Department, sufficient amounts of spalls or base material to bring the roadbed to a line 3 inches below the grading line.

Where the Plans require placement of sod on rock cuts, remove the rock to 1 foot below the grading line and backfill to grade with earthen material before placing the sod.

Where boulder formations occur, scarify the roadbed in the excavation area and remove all boulders to a depth of 12 inches below grade. Backfill and compact resulting cavities with suitable material.

C. Presplitting and Blasting

Presplit all rock cuts at the outside limits of the cut areas. Presplitting shall consist of forming a plane of split rock, for the entire depth of the cut or to a predetermined bench level, prior to any primary blasting.

To accomplish presplitting, drill holes of appropriate size to the desired depth along the outside limits of the cut area, load such holes with appropriate charges of explosives, stem with minus 3/8-inch clean stone chips to the collar of each hole, and simultaneously detonate the charges. The initial horizontal spacing of holes and vertical spacing of

charges and blasting cord for simultaneous detonation shall be as recommended by a reliable powder company. Adjust horizontal hole spacing and vertical spacing of charges as necessary to obtain a relatively smooth shear plane. Do not use sand, gravel, clay, or dirt for stemming. In drilling holes for presplitting, ensure that the drills are plumbed for vertical slopes or set on the required slope when other than vertical slopes are specified, and that all holes are drilled in the same plane. Presplitting will not be required on slopes flatter than 1:1. Presplit rock cuts under bridge sites as specified in this Subsection, but comply with the hole spacing specified in **204.08.A**.

After presplitting is done, drill primary blast holes at least 3 feet from the presplit face. Provide blasting records to the Engineer upon request. Do not perform blasting within 300 feet of any structure or concrete until at least 72 hours after concrete placement. Replace and/or repair all damage associated with blasting operations at no cost to the Department.

D. Unsuitable Soil

The Engineer will designate as unsuitable those soils that cannot be properly compacted in embankments. Dispose of all unsuitable soil as directed and at no additional cost to the Department.

If the location of unstable soil is shown on the Plans, remove and replace as shown.

E. Borrow Areas

Notify the Engineer before opening any borrow area to allow adequate time for the Engineer to take cross-section elevations and measurements of the ground surface after being stripped, and to test the borrow material before use. Obtain approval for the borrow area according to the manual *Procedures for Providing Offsite Waste and Borrow on TDOT Construction Projects*. Allow at least 14 days for testing borrow materials or other material from roadside pits proposed for construction purposes.

Unless otherwise allowed, do not place borrow material until after the roadway excavation material has been placed in the embankments. If the Contractor places more borrow than is required and thereby causes a waste of excavation, the Department will deduct the amount of such

waste from the measured borrow volume. Do not excavate beyond the dimensions and elevations established.

The Contractor may remove highway fencing to obtain borrow materials. Replace the fencing removed with new fence at no cost to the Department, and assume responsibility for confining livestock, as necessary.

Excavate borrow pits to be self-draining where possible and practicable, and of a shape that can be easily cross-sectioned.

After completing excavation operations, provide the area with a neat appearance. Cover all self-draining borrow areas with topsoil and stabilize according to the manual *Procedures for Providing Offsite Waste and Borrow on TDOT Construction Projects*. Provide and place topsoil and seeding (with mulch) as specified in **203.06** and **801**, respectively.

For borrow pits 1 acre or larger in size that are not self-draining, refer to Sections 53-801 through 53-809 of the TCA. Full information regarding the requirements to be complied with and the necessary permits that the property owner must secure for the construction of a pond, lake, borrow pits, etc., 1 acre or larger that is not constructed to drain, will be supplied upon application to the TDEC.

203.05 Undercutting

The Department will designate areas to be undercut on the Plans if appropriate information is available. However, the Engineer may increase, decrease, or shift such designated areas as conditions require during construction.

Backfill undercut areas with suitable material from within the grading balance, or in the first 1,000 feet of the adjacent balances if obtainable. If road and drainage excavation is not available, use borrow excavation as backfill.

Conduct operations so that the Engineer can take the necessary cross-sectional measurements.

Compact backfill materials as specified in **205**.

If disposing of undercutting material off the right-of-way, adhere to the manual *Procedures for Providing Offsite Waste and Borrow on TDOT Construction Projects*, and obtain advance approval for the disposal site from the Engineer, Environmental Coordinator, and the Environmental Division.

203.06 Stripping, Stockpiling, and Placing Topsoil

The Engineer will designate areas for stripping and stockpiling existing topsoil between slope stake points in both cut and fill areas. Strip the quantity of material necessary to cover all areas to be seeded with 2 to 3 inches of topsoil. If the quantity of topsoil available in such areas is insufficient, obtain additional topsoil from an approved borrow area according to the manual *Procedures for Providing Offsite Waste and Borrow on TDOT Construction Projects*.

The Engineer will designate areas to be deleted from stripping operations because of rock or other unsuitable material.

Before performing stripping operations, notify the Engineer. Stockpile the stripped topsoil in the areas designated by the Engineer. Neatly dress each stockpile, when completed, to facilitate measurement.

Immediately before the Contractor prepares an area for seeding, the Engineer will take cross-section measurements of the topsoil stockpiles. Until the construction sequence for seeding has been established and is ready to proceed, the Engineer will not cross-section stockpiles, and the Contractor shall not spread topsoil.

Place a 2 to 3-inch layer of topsoil on all areas requiring seeding or sod, except for cut slopes steeper than 2:1. On cut slopes steeper than 2:1 that require seeding or sod, spread topsoil to a depth of 1 to 2 inches, as directed by the Engineer. Cover rock slopes and other rock areas that require seeding with 9 inches of suitable material and 2 to 3 inches of topsoil. After placing the stockpiled topsoil, neatly dress the former stockpile areas and allow the Engineer to take final cross-sections.

203.07 Disposing of Excess or Unsuitable Material

Use excess excavation material to raise, widen, or flatten the slopes of embankments; to fade embankments into cuts; or to place in such other locations and for such purposes as the Engineer may direct.

The Engineer will provide specific instructions regarding the disposal of surplus material. Place and compact excess or unsuitable material within the right-of-way limits as specified **205.04**. Foundation preparation for and drainage through these waste areas shall be equivalent to that provided for the adjacent roadway embankment.

If no suitable place can be found to dispose of excess or unsuitable material within the right-of-way, the Engineer may direct the Contractor to provide a suitable offsite disposal area at no additional cost to the Department in accordance with the manual *Procedures for Providing Offsite Waste and Borrow on TDOT Construction Projects*.

When placing waste material off the right-of-way in areas which, in the judgment of the Engineer, are so removed from the right-of-way as to not constitute a potential threat to the stability of the Project, follow the manual *Procedures for Providing Offsite Waste and Borrow on TDOT Construction Projects* to ensure the waste area is properly designed, regulated, and implemented.

203.08 Shaping and Dressing

Trim and shape the slopes of all excavated areas, ditches, waterways, channels, borrow pits, and embankments so as to be in reasonably close conformity with the cross-sections shown on the Plans or as directed by the Engineer.

Scale all loose fragments, projecting points, and debris from rock cuts, and leave in a neat, safe, and workmanlike condition.

Dispose of excess material created by trimming slopes, resloping, and shaping as specified in **203.07**.

Perform Final Dressing as specified in **206**.

COMPENSATION

203.09 Method of Measurement

Where excavation of different classifications overlap, the following order of measurement and computation for payment applies:

1. Road and Drainage Excavation (Unclassified) or Channel Excavation (Unclassified) shall supersede Structure Excavation and Foundation Preparation. Road and Drainage Excavation (Unclassified) shall supersede Channel Excavation (Unclassified).

2. Excavation, the cost of which is included in lump sum items or the unit price bid for other items of construction, shall supersede all other classifications.

Excavation of embankment will not be measured for payment unless the Engineer approved the excavation in writing.

Where it is impracticable to measure material by the cross-section method due to the erratic location of isolated deposits, the Department may use methods involving three-dimensional measurements.

The Department will measure water used in the work by the M.G. (1,000 gallons) using calibrated tanks or distributors, or accurate water meters.

A. Road and Drainage Excavation

1. The Department will measure Road and Drainage Excavation by the number of cubic yards of material, acceptably excavated, measured in its original position by cross-sectioning the area excavated. The Engineer may determine cross-sections from conventional manual surveys, aerial surveys, Digital Terrain Modeling, or a combination of these methods.

2. The Department will measure excavation required to bench side-hill slopes of embankment construction as follows:

    a. Excavation in solid rock will be paid for as Road and Drainage Excavation (Unclassified) whether the excavation material is bladed and dozed or picked up and hauled.

    b. For excavation in other than solid rock:

        (1) The Department will measure excavated material that is picked up and hauled as Road and Drainage Excavation (Unclassified).

(2) The Department will not directly measure excavation material moved by blading or dozing and will consider such work as incidental to other items.

3. When the Plans specify or the Engineer directs that rock embankment material be obtained from the roadway excavation, all costs of constructing the rock embankment material, including, but not limited to, excavating, reserving, hauling and placing, will be measured and paid for under the item for Road and Drainage Excavation (Unclassified) and no additional compensation will be made for this work.

4. Authorized excavation of rock, shale, or unsuitable material below grade consists of that excavation necessary to provide the designed thickness of backfill. If the plane of the designated bottom of excavation falls within a layer or stratum of rock, the below-grade excavation to the bottom of the layer, not exceeding 3 inches below grade, will be considered as authorized and will be measured for payment. If the Engineer directs the Contractor to use approved base material to bring portions of the roadway that are less than 3 inches below grade up to grade, the Department will measure and pay for the furnishing and placing of such base material in tons under the applicable item in **303.15**. If base material is not a bid item in the Contract, the Contractor shall provide the material under the provisions of **104.02.D**.

   If the roadway is excavated in excess of 3 inches below the grading line shown on Plans, the Contractor shall furnish and place, at no cost to the Department, sufficient amount of spalls or approved base course material, or other suitable approved granular material, to bring the roadway to a line 3 inches below the grading line.

B. Road and Drainage Excavation (Additional Material)

1. If the Engineer adjusts the slopes shown on the original cross-sections, depresses raised medians or islands, or flattens, widens, or daylights cuts, the Department will measure the additional material thus obtained in cubic yards under Road and Drainage Excavation (Additional Material).

2. If additional material is paid for under the item for Road and Drainage Excavation (Additional Material) and additional clearing and grubbing is required, the Department will measure and pay for

the additional clearing and grubbing by the acre, provided the item for Adjusted Clearing and Grubbing is in the Contract, or as negotiated. No additional payment will be made for extra handling of stockpiled topsoil made necessary by the use of the item for Road and Drainage Excavation (Additional Material).

C. Borrow Excavation

The Department will measure and pay for Borrow Excavation by the cubic yard in accordance with **109**.

D. Presplitting

If the Contract contains an item for Presplitting, the Department will measure presplitting of rock cuts by the number of square yards of rock face determined by multiplying the difference in elevation in yards between the bottom and top of face at each station and intermediate stations (where break sections are needed to accurately show the work) by the length of face in yards taken from cross-sections. If the Contract does not have an item for Presplitting, the required presplitting shall be included in the price bid for Road and Drainage Excavation or Channel Excavation (Unclassified).

E. Undercutting

1. The Department will measure unsuitable materials excavated and removed to obtain proper compaction in cut sections, in foundations for fill sections, and for pipe and box culverts in accordance with **204.12**. The removal and disposal of this unsuitable material will be classified as Undercutting, unless otherwise specified.

2. The Department will not measure suitable material temporarily removed and replaced to facilitate compaction of the material for the full depth shown on the Plans.

3. The Department will measure Undercutting by the cubic yard based on cross-sectional measurement or the most feasible method.

F. Topsoil

1. Except for topsoil obtained from a source outside the right-of-way, the Department will measure and pay for stripping and stockpiling

of topsoil as Unclassified Excavation by the cubic yards of material in its original position.

2. The Department will measure the Placing and Spreading of stockpiled topsoil on slopes and elsewhere within the right-of-way by the cubic yards of material in the stockpile as determined using the cross-section method.

3. Furnishing and Spreading Topsoil obtained from an approved borrow source located outside the right-of-way will be measured by the cubic yards of material removed as determined by cross-sectioning the area before and after removal.

203.10 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Road and Drainage Excavation (Unclassified)	Cubic Yard
Road and Drainage Excavation (Additional Material)	Cubic Yard
Channel Excavation (Unclassified)	Cubic Yard
Borrow Excavation (_____)	Cubic Yard or Ton
Presplitting of Rock Excavation	Square Yard
Undercutting	Cubic Yard
Placing and Spreading Topsoil	Cubic Yard
Furnishing and Spreading Topsoil	Cubic Yard
Water	M.G.

Such payment is full compensation for providing all materials, including hauling excavation and borrow, and providing all equipment, labor, and incidentals to complete the work as specified.

The Department will pay for Road and Drainage Excavation (Additional Material) at a rate per cubic yard equal to 1.5 times the contract unit price for Road and Drainage Excavation (Unclassified).

The Department will pay for excavation required to correct slides, regardless of its location relative to the theoretical slope line, or excavation required to prevent potential slides including blasting, and the dressing, reshaping or flattening of the affected slopes as directed by the Engineer, under the item for Road and Drainage Excavation (Additional Material). If

it becomes necessary to flatten a slope to correct a slide or prevent a potential slide after the cut has been started but not completed, payment under Road and Drainage Excavation (Additional Material) will be limited to material removed between the original staked slope line and the newly established slope line above the elevation to which the cut has been made. The Department will pay for all other material at the contract unit price of Road and Drainage Excavation (Unclassified). Seeding, sod and other items required to repair the slide area will be paid for at the contract unit price bid for the respective items.

The Department will pay for Undercutting at the contract unit price per cubic yard. If unsuitable material not described in the Plans is encountered and no contract unit price has been established for Undercutting, the Department will pay for this work at a rate per cubic yard equal to 1.5 times the contract unit price for Road and Drainage Excavation (Unclassified) due to the nature of the unforeseen, slower production work. However, if the unsuitable material is known and described in the Plans and has been accounted for in grading quantities (either Undercutting or Road and Drainage), it will be paid at the contract bid price.

If the Plans require placement of sod on rock cuts, the Department will pay for rock removal, earthen backfill, and sod placement under Road and Drainage Excavation (Unclassified) and Sodding (New Sod).

The Department will pay for furnishing and placing topsoil and seeding waste areas inside the right-of-way at the contract unit prices for the respective items. The Department will not directly pay for furnishing and placing topsoil and seeding waste and borrow areas located outside the right-of-way.

The Department will pay for the removal of concrete pavement, base, parking strip, and sidewalk, curb and gutter, and similar features under the classifications specified in **202.06** and **203.02.A**.

The Department will pay for roadway obliteration as Road and Drainage Excavation (Unclassified). The Department will pay for the application of topsoil and seed to obliterated roadways under the items for Topsoil and Seeding.

SECTION 204 – STRUCTURE EXCAVATION FOUNDATION PREPARATION, AND BACKFILL

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DESCRIPTION

204.01 Description

This work consists of excavation, foundation preparation, and backfill for the installation or construction of bridges, culverts, underdrains, and other structures not otherwise provided for in the Specifications.

This work also includes constructing and subsequently removing all bracing, shoring, cribbing, and cofferdams, all pumping and bailing, backfilling, and disposing of excess or unsuitable material.

204.02 Classification

The Department will classify and pay for Structure Excavation and Foundation Preparation under the following designations:

A. Culvert Excavation (Unclassified)

Structure Excavation and Foundation Preparation performed within the limits specified in **204.08** and **204.10**, for all box bridges, pipe culverts, sewers, conduits, all other culverts, all minor structures of any type and description, will not be measured and paid for directly but the cost will be incidental to other items, unless otherwise shown on the Plans.

B. Dry Excavation (Bridges)

Structure Excavation and Foundation Preparation performed above the datum line (established by elevation and definitely shown on the Plans) and within the limits specified in **204.08.A** and **204.10.A** and not classified as Rock Excavation (Bridges), as indicated or directed, will be classified and paid for as Dry Excavation (Bridges).

C. Wet Excavation (Bridges)

Structure Excavation and Foundation Preparation performed below the datum line (established by elevation and definitely shown on the Plans) and within the limits specified in **204.08.A** and **204.10.A** and not classified as Rock Excavation (Bridges), as indicated or directed, will be classified and paid for as Wet Excavation (Bridges).

D. Rock Excavation (Bridges)

Structure Excavation and Foundation Preparation performed either above or below the datum line (established by elevation and definitely shown on the Plans) and within the limits specified in **204.08.A** and **204.10.A** and consisting of material which cannot be economically excavated without the use of explosives, also any boulder, slab, or fragment of rock having a volume of not less than 1/2 cubic yards, all Portland cement concrete, all masonry (dry mortar), as indicated or directed, will be classified and paid for as Rock Excavation (Bridges).

Cemented gravel, cemented chert, soft shale, or soft slate, even though requiring the use of explosives for economical excavation, will not be classified as rock.

E. Bridge Excavation (Unclassified)

Bridge Excavation (Unclassified) shall be structure excavation and foundation preparation performed either above or below the datum line

(established by elevation and definitely shown on the Plans) as stipulated in **204.08.A** and **204.10.A** regardless of the nature of the material excavated.

F. Rock Drilling (Bridges)

Rock Drilling includes the drilling or sinking of test holes through or in rock to verify the condition of the foundation.

MATERIALS

204.03 Foundation Fill Material

Material for foundation fill shall consist of suitably graded sand, gravel, slag or stone, as approved by the Engineer.

204.04 Bedding Material

A. Support for Pipe Culverts

For Class A bedding, use Portland Cement Concrete, Class A.

For Class B bedding, use sand or a natural sandy soil, all of which passes a 3/8-inch sieve and not more than 10% passes a No. 200 sieve, or stone, gravel, chert, or slag meeting the grading requirements for either Grading C, D, or E of **903.05**.

B. Areas Requiring Free Drainage Material

In rock cuts or other areas designated by the Engineer that require a free drainage bedding or backfill material, provide crushed stone, crushed slag, or washed gravel meeting **903.17**.

204.05 Concrete

Concrete shall conform to **604**. Unless otherwise shown on the Plans or in the Special Provisions, use Class S concrete for foundation seals that meets the requirements of **604.18**. Concrete for culvert pipe cradles shall be Class A.

204.06 Backfill Material

A. General

Material for backfill shall be fine compatible soil selected from structure excavation if approved by the Engineer as being suitable. Obtain additional material needed from roadway or borrow excavation as specified in **203.**

Granular Backfill Material for Structures shall be Type A aggregate, Grading D meeting **903.05**.

B. Flowable Fill

If shown on the Plans, place as backfill material a controlled low strength material (CLSM) (flowable fill) at the locations shown on the Plans or as directed by the Engineer.

Materials used in the placement of CLSM shall meet the following requirements:

Portland Cement, Type I	**901.01**
Fine Aggregate	**903.01**
Water	**921.01**
Chemical Additives	**921.06**
Air Entraining Admixtures	**921.06.A.2**
Fly Ash, Class C or Class F	**921.15**
Ground granulated blast furnace slag (GGBFS)	**921.16**

Submit for approval a proposed mix design for CLSM as specified in **604.03**.

As defined herein, there are three types of CLSM: general use flowable fill, excavatable flowable fill, and early strength flowable fill.

As part of acceptance testing, the Department will determine the consistency of CLSM in accordance with the procedure described below. This method applies to each of the aforementioned types of CLSM.

1. Place an inverted slump cone on a smooth, level surface.

2. Fill the inverted slump cone with a representative sample of the flowable fill without rodding in one lift.

3. Remove the slump cone by lifting it straight up, thus allowing the sample to diffuse on the smooth, level surface.

4. The flowable fill should diffuse into a circular shape having an approximate diameter of not less than 15 inches.

Each consistency test will represent up to 100 cubic yards of flowable fill at each installation.

The Engineer may adjust the Specification Limits identified below to obtain the consistency required for satisfactory flow.

1. General Use Flowable Fill. When not otherwise shown on the Plans, or specified in the Contract, provide general use flowable fill proportioned to meet the limits specified in Tables 204.06-1 and 204.06-2.

Table 204.06-1: Proportioning General Use Flowable Fill

Material	Requirement (per Cubic Yard)
Cement	100 pounds
Fly Ash	250 pounds (minimum)
Fine Aggregate	2,800 pounds
Water	60 gallons (approximate)

Table 204.06-2: Specification Limits for General Use Flowable Fill

Property	Specification Limit
Load Application (ASTM D6024)	24 hours maximum in any condition
Consistency	8 inches minimum tested as specified in this **204.06.B.1**

2. Excavatable Flowable Fill (EFF). If shown on the Plans, design, proportion, and deliver to the Project an EFF that meets the performance requirements specified in Table 204.06-3.

Table 204.06-3: Specification Limits for EFF

Property	Specification Limit
Air content (ASTM D6023)	Maximum 30% (1)
Load Application (ASTM D6024)	24 hours maximum in any condition
Consistency	8 inches minimum as tested per **204.06.B.1**
Compressive strength (ASTM D4832) (2)	30 psi minimum at 28 days

(1) When using air entrained mixture design

(2) ASTM D4832 4 x 8 inch cylinder molds may be used. The preferred capping method to be used is wetsuit neoprene restrained in rigid retainers.

During the mixture design process, direct the ready mix producer to complete a test trench, at least 3 feet wide by 3 feet deep by 8 feet long, with the proportioned materials to demonstrate the mixture will meet the performance criteria. The Contractor may adjust the mixture design with the Engineer's approval to obtain the required properties.

3. **Early Strength Flowable Fill (ESFF).** If shown on the Plans, design, proportion, and deliver to the Project ESFF that meets the performance requirements specified in Table 204.06-4.

Table 204.06-4: Specification Limits for ESFF

Property	Specification Limit
Air content (ASTM D6023)	Maximum 30% (1)
Load Application (ASTM D6024)	6 hours maximum in any condition
Consistency	8 inches minimum as tested per **204.06.B.1**
Compressive strength (ASTM D4832) (2)	30 psi minimum at 24 hours

(1) When using air entrained mixture design

(2) ASTM D4832 4 x 8 inch cylinder molds may be used. The preferred capping method to be used is wetsuit neoprene restrained in rigid retainers.

Include in the proportions of ESFF sufficient amounts of cementitious materials, high range water reducers, accelerators, and other chemical admixtures so the ESFF can be loaded/backfilled as specified.

During the mixture design process, direct the ready mix producer to complete a test trench, at least 3 feet wide by 3 feet deep by 8 feet long, with the proportioned materials to demonstrate the mixture will meet the performance criteria. The Contractor may adjust the mixture design with the Engineer's approval to obtain the required properties.

Provide an approved Concrete Daily Report, and furnish the resources, information, and tools that will meet the requirements of **501.03.B**. To produce the desired consistency, the Contractor may use chemical additives, air entraining admixtures, or both, at no additional cost to the Department.

204.07 Reserved

CONSTRUCTION REQUIREMENTS

204.08 Excavation

A. Bridges, Box Culverts and Other Major Structures

Before the start of excavation, the Engineer, or Contractor when required, will set stakes locating and outlining the structure and cross-section for excavation computations.

Before starting excavation, clearly mark the limits of disturbed area and undisturbed area using highly visible markers that are readily visible to project personnel including equipment operators.

Excavate to the lines and elevations shown on the Plans or as directed by the Engineer. The Engineer will allow working variations outside the neat lines; however, the Department will only measure that excavation specified in **204.12** for payment.

Do not deposit or dispose of any excavated materials outside the construction lines unless directed and approved by the Engineer according to the manual *Procedures for Providing Offsite Waste and Borrow on TDOT Construction Projects*.

If solid rock is encountered in roadway cut sections and channel sections under bridges, perform presplitting operations as specified in **203.04.C**. Hole spacing along bridge abutment sites shall not exceed 12 inches. If overshooting of rock beyond the cut sections shown on the bridge plans requires modification of bridge abutments or span lengths, make such modifications at no additional cost to the Department.

Excavate inclined surfaces of rock used as foundation either level or in steps. When necessary to obtain good bond, as determined by the Engineer, roughen the surface of rock foundation or install suitable anchors. Over-excavations that require re-design, increased bridge length, quantities, or both, or supplemental retaining walls or other earth retaining structures, shall be at no additional cost to the Department.

Remove existing concrete foundations, boulders, or ledge streaks of rock projecting into the bottom of the excavation to a depth of 6 inches below foundation elevation. Backfill and compact the resulting cavity with approved material.

Only excavate below the specified bridge foundation elevations as directed by the Engineer. Replace, at no cost to the Department, all materials moved without such authority by constructing a sub-footing of the same materials as the footing of the structure unit and 6 inches wider on every side.

B. Pipe Culverts

Excavate for pipe culverts as specified in **204.08.A** and as follows:

1. The width of the pipe trench shall be as shown on the Plans to allow satisfactory joining of the pipe, thorough tamping of the bedding material under and around the pipe, and placement of flowable fill.

2. Remove rock, hardpan, or other unyielding material encountered in the pipe trench to below the foundation grade for a depth of 6 inches, or as directed by the Engineer.

C. Use of Excavated Materials

Use suitable excavated material as backfill or embankment. When disposing of excess or unsuitable material, do not obstruct the stream or otherwise impair the efficiency or appearance of the structure. Deposit excavated material so as not to damage a partly finished structure.

Carefully handle, deposit, and protect excavated materials that will be incorporated in the structure.

In streams, dispose of material according to the laws of the U.S. Government, the requirements in the TN Construction General Permit, and all other applicable environmental permits.

204.09 Protection of Excavation

Protect excavation areas, and ensure that the excavation remains intact.

If OSHA regulations require shoring, submit to the Engineer, prior to starting work, computations and drawings, prepared by and stamped by a Professional Engineer licensed in the State of Tennessee, showing the basis for the design.

If using cofferdams or cribs for foundation construction, ensure that they are carried to sufficient depths below the bottom of the footings, are substantially braced in all directions, and are as watertight as necessary for proper performance of the work.

When dewatering work areas, comply with the requirements of the TN Construction General Permit, and do not violate water quality standards. Unless otherwise shown on the Plans, construct cofferdams so that the interior dimensions provide sufficient clearance for the construction and inspection of forms, and to allow for pumping of leakage outside of the footing area. If cofferdams or cribs tilt or move out of position during the process of sinking, right, reset, or enlarge them to provide the necessary clearance at no additional cost to the Department.

Construct cofferdams or cribs so as to protect the foundation and the construction therein against damage from a rise in the stream.

With the Engineer's written permission, obtained before the start of cofferdam or crib construction, the Contractor may extend timber, or bracing of a cofferdam or crib, into or through the substructure. Do not brace the cofferdams for structure widening off of the existing structure.

Before starting any work, submit drawings to the Engineer, prepared and stamped by a Professional Engineer licensed in the State of Tennessee, showing details of the proposed cofferdam or crib construction. The type and clearance of cofferdams, or cribs, insofar as they affect the finished structure or part thereof, will be subject to the Engineer's approval, but the design and successful construction of cofferdams or cribs is the Contractor's responsibility. Do not begin work in a stream without receipt of the applicable permits from State and Federal agencies. Ensure that cofferdam construction is in accordance with all permit requirements.

Unless otherwise directed, remove cofferdams or cribs, with all falsework, sheeting, bracing, and related appurtenances, after completing the sub-structure therein, unless otherwise directed. Complete the removal without disturbing or marring the completed work.

If the foundation excavation becomes disturbed or distorted, clean out and restore it to satisfactory condition at no additional cost to the Department.

204.10 Foundation Preparation

A. Bridges, Box Culverts, and Other Major Structures

Prepare foundations for bridges, box culverts, and other major structures according to the following:

1. After completing the foundation to the specified elevation, notify the Engineer and await the Engineer's inspection and approval before resuming construction therein.

2. When directed by the Engineer, unless piles are indicated, test each foundation in the presence of the Engineer by sinking three to six test holes to a depth of between 6 and 10 feet.

   If these test holes reveal unsatisfactory foundation conditions, continue the excavation lower, as directed by the Engineer, and conduct new tests until a satisfactory foundation is obtained.

3. If rock is encountered in the excavation for the foundation, remove loose fragments and debris and notify the Engineer. Drill test holes in the rock as shown on the Plans or as directed by the Engineer to determine the lines of demarcation, the classification, and the stability of the rock. Continue the excavation to the elevation designated by the Engineer. If required by the Engineer, drill test holes and continue excavation until a foundation approved by the Engineer is secured.

   Strip and clean rock used as foundation of all overlying materials. Remove all loose, disintegrated, or light slabby portions of the rock.

   In rock foundations, if the rock is shattered below the foundation elevation, remove the shattered material and rebuild the resulting space with the same type of construction as the proposed overlying construction, at no additional cost to the Department.

4. If the Plans require driven piles, or if after the foundation excavation has been completed it becomes necessary to reinforce the foundation by driving piles, remove any resulting bulges of the foundation material, at no additional cost to the Department, to the elevation indicated or directed, and bring the foundation to an even surface over its entire area.

5. Remove unsatisfactory material in the foundation and replace with satisfactory material designated by the Engineer. Place the satisfactory material in layers not exceeding 6 inches in loose depth and compact to 100% of maximum density up to the foundation elevation.

6. If pumping from the interior of a foundation enclosure, prevent the possibility of concrete material being carried away. Use a suitable sump located outside the concrete forms to perform any pumping required during the placing of concrete, or for a period of at least 24 hours thereafter. When dewatering work areas, comply with the requirements of the TN Construction General Permit, and do not cause a water quality violation.

7. If conditions make it impracticable to dewater the foundation before placing the footing, the Engineer may allow the Contractor to construct a concrete foundation seal of the dimensions and thickness necessary to resist possible uplift.

    a. Before pouring the seal, clean the foundation of all objectionable material using sand pumps, spud bars, or other suitable means.

    b. Construct the seals as specified in **604.18**.

    c. Allow the seal to set sufficiently to withstand the hydrostatic pressure before starting pumping for dewatering operations.

    d. Dewater the foundation and thoroughly clean the seal of all laitance and ensure that it is generally prepared for further construction.

B. Pipe Culverts

Bedding for pipe culverts shall conform to the requirements for Class A, B, or C bedding, whichever is shown on the Plans or in the Special Provisions. If the class of bedding is not shown, place Class C bedding.

1. **Class A Bedding.** Construct a continuous concrete cradle as shown on the Plans and as specified in **604**.

2. **Class B Bedding.** Cut a trench in natural ground or compacted embankment to the depth shown on the Plans. Place 6 inches of Class B Material, along with sufficient additional Class B material accurately shaped by a template to fit the lower part of the pipe exterior for at least 10% of its overall height. If the Plans require flowable fill, place flowable fill around the pipe as specified in **204.11.C**. Otherwise, ram and tamp Class B material in layers of not more than 6 inches in loose thickness around the pipe to a minimum depth as shown on the Plans. Backfill and compact the remaining depth of trench as specified in **204.11.B**.

   If placing bell and spigot pipe, dig recesses in the bedding material of sufficient width and depth to ensure that the bell will not rest on the bottom of the recess. The width of the recess shall not exceed the width of the bell by more than 2 inches.

   For plastic pipe, the bedding and backfill shall be granular compactable Type A or Type B Aggregate, Grading D or E material meeting **903.05**. Do not use open graded aggregates. Place a minimum of 6 inches of bedding and compact to a minimum 90% Standard Proctor Density before placing the pipe unless otherwise specified.

3. **Class C Bedding.** Cut a shallow trench in natural ground or compacted embankment to a depth of not less than 10% of the outside vertical pipe diameter, and shape to fit the lower pipe exterior for the specified embedment. If placing bell and spigot pipe, dig recesses in the earth foundation of sufficient width and depth to ensure that the bell will not rest on the bottom of the recess. The width of the recess shall not exceed the width of the bell by more than 2 inches.

204.11 Backfilling

Place all backfill, other than flowable fill, which will become a part of the roadway prisms or their foundations, in layers, and compact to 100% density as specified in **205.04**. Place flowable fill, if called for on the Plans, as specified in **204.06.B**.

A. Bridges, Box Culverts, and Other Major Structures

Backfill all excavated areas not occupied by structures with acceptable earth material to the normal ground surface, unless otherwise directed. Place backfill in layers, not more than 6 inches in loose depth for mechanical tamps and 10 inches in loose depth for tamping rollers, on both sides of the structure or around the structure unit, maintaining the layers at equal elevation and thoroughly compacting each layer by tamping with suitable rapid-striking power-driven mechanical tampers or sheepsfoot rollers before placing the succeeding layer.

Place Granular Backfill Material for Structures (Class A, Grading D) so that the compacted depth does not exceed 6 inches per layer. Compact every 6-inch layer to 100% density.

If any part of the structure is to function as a retainer for backfill, such as abutments, retaining walls, wing walls, arches, side walls of box culverts, or minor structures, step the boundary slopes as necessary to prevent wedge action during backfilling.

Do not place backfill against a structure or any section or unit thereof, until the following conditions have been met:

1. Forms have been removed and concrete surfaces have been finished as specified in **604.21** and **604.22**, respectively;

2. Representative specimens of the structural concrete, cured by the same methods and in the same manner as the concrete in the structure, attain a compressive strength of 3,000 psi; and

3. The concrete has been in place a minimum of 7 days, not counting the days of 24 hours each in which the temperature falls below 40 °F, or 21 calendar days, whichever occurs first.

When backfilling behind abutments held at the top by a superstructure, and behind the sidewalls of culverts, bring up backfill simultaneously behind abutments or sidewalls.

Promptly backfill box culverts and bridge ends after the strength requirements have been met, but no longer than 30 days following strength attainment, and before placing a bridge deck, or as directed by the Engineer.

B. Pipe Culverts

When material meeting **903.17** is used for Class B bedding, the Engineer will waive compaction and density requirements. The Contractor may increase lift thickness up to a maximum of 3 feet after the material has been thoroughly forced under the haunches of the pipe.

1. **Placing Backfill Material.** After the bedding has been prepared and the pipe installed, backfill the trench with bedding material, fine compactable soil selected from excavation or borrow, or both, as shown on the Plans. Before backfilling concrete pipe, allow the joints to cure as specified in **607.07**. Place the material along each side of the pipe in layers not more than 6 inches in loose depth. Moisten or dry, if necessary, each layer to near optimum moisture content and thoroughly compact with mechanical tampers. Thoroughly compact the material under the haunches of the pipe and ensure that the backfill material is in intimate contact with the side of the pipe. Uniformly place and raise backfill on both sides of the pipe for the full required length. Except as may be required for the imperfect trench method, place backfill material for the full depth of the trench.

2. **Placing Embankment Material.** When the top of the pipe is above the top of the trench, place and compact embankment material in layers of not more than 6 inches in loose depth for a width on each side of the pipe equal to at least twice the horizontal inside diameter of the pipe or 12 feet, whichever is less. The embankment on each side of the pipe, for a distance equal to the horizontal inside diameter of the pipe, shall be of the same material and compacted in the same manner as specified for backfill in **204.11.B.1**. For the remainder of the fill material, use soil that can be readily compacted and that contains no frozen lumps, chunks, or plastic clay, stones that would be retained on a 3-inch sieve, or other objectionable material. Compact the material as required for

backfill or by rolling as specified in the applicable requirements of **204**. Place the embankment material evenly on both sides of the pipe for the full width of the roadbed up to an elevation a minimum of 1 foot above the top of the pipe. Above this elevation, and also above the top of a backfilled trench that is 1 foot or more above the top of the pipe, place embankment as specified in the applicable requirements of **205**, except for those requirements related to the imperfect trench method.

3. **Plastic Pipe.** For plastic pipe, work structural backfill into the haunch area and compact the materials by hand after placing the pipe. Special compaction means may be necessary in the haunch area. Place structural backfill in layers of not more than 6 inches in loose lift thickness and bring up evenly and simultaneously on both sides of the pipe to an elevation not less than 1 foot above the pipe. Use a vibratory plate to achieve a minimum compaction level of 90% Standard Proctor Density according to AASHTO T 99. Do not use hydrohammer type compactors over the pipe. Obtain the Engineer's approval of all compaction equipment.

4. **Imperfect Trench Method.** When the Plans require the imperfect trench method, bed the pipe, backfill the trench, and place the embankment as specified in **204.11.B.1** and **204.11.B.2**, to a height above the top of the pipe equal to the vertical outside diameter of the pipe plus 1 foot. Excavate a trench equal in width to the outside horizontal diameter of the pipe in the newly placed backfill or embankment directly over the pipe, keeping the trench walls as nearly vertical as possible, and down to an elevation 1 foot above the top of pipe. Backfill the lower 1/4 of the trench with straw or other highly compressible material. Backfill the remainder of the trench with the excavated trench material deposited in the loosest possible manner. After completing the trench backfill, construct the remainder of the embankment by normal methods to the finished grade line.

C. Backfill Material (Flowable Fill)

Place flowable fill at the locations shown on the Plans or as directed by the Engineer. Cover or otherwise protect the flowable fill while in the plastic state. Do not place embankment or base materials on the flowable fill prior to final set or hardening as determined by the Engineer.

Before placing flowable fill, install pipe and bedding as specified herein and as shown on the Plans. Securely brace or anchor all sections of pipe both horizontally and vertically, if necessary, to prevent movement of the pipe during placement of the flowable fill. Join pipe sections so as to prevent the influx of flowable fill around the joints. Replace, at no cost to the Department, all pipe or sections of pipe that cannot withstand placement of flowable fill. Make provisions to form up, or provide earthen berms, to prevent the flowable fill from escaping at the ends of the trench and around headwalls.

COMPENSATION

204.12 Method of Measurement

The normal ground surface, as used in this Section, is defined as the bottom of channel excavations when channel excavation is indicated in the contract documents, the template section of the roadway in cuts, or the natural ground surface, whichever is at the lower elevation. When structure excavation is required in new embankment, the normal ground surface shall be the planes of the new embankment at the elevation specified or directed for construction in advance of performing the required structure excavation, but in no case shall the normal ground surface be above the planes of the new embankment.

A. Structure Excavation

1. The Department will measure structure excavation by the cubic yards of material in its original position only.

2. The Department will measure excavation necessary to construct box bridges, box culverts, retaining walls or minor structures, including pipe culverts and sewers, as follows:

    a. Unless otherwise shown on the Plans, no allowance will be made for excavation, except that undercutting for these structures made at the direction of the Engineer to remove unsuitable foundation material will be classified and paid under the item for Undercutting, in accordance with **203.10**.

    b. If the Plans provide for direct payment of excavation, the excavation, including undercutting made at the direction of the Engineer to remove unsuitable foundation material, will be

classified and paid for as Culvert Excavation (Unclassified) with the following exception:

Excavation within the limits of box bridges, box culverts with a bottom width between the inner faces of the outside walls greater than 14 feet, that is performed above the flow line of the structure, and with a bottom width equal to the distance between the inner faces of the outside walls on a 1:1 slope to the normal ground surface, will be measured and paid for under the item for Channel Excavation (Unclassified).

3. If the Plans provide for direct payment of excavation, the Department will measure the actual volume of material excavated, provided it does not extend beyond the following limits of excavation:

   a. For box bridges, box culverts, retaining walls or minor structures, including pipe culverts and sewers, the volume of Culvert Excavation (Unclassified) measured will extend horizontally to the vertical planes located 18 inches outside the neat lines of the section of the structure at foundation elevation, as indicated or directed, and vertically between the normal ground surface and the foundation elevation, as approved. For box bridges and box culverts without bottom slabs, the foundation elevation is considered to be the bottom of footings and the flow line elevation between footings. No allowance will be made for overlapping areas.

   b. Where internal forming is required, as for cut off walls and similar features, the quantity measured will extend horizontally 12 inches outside the neat lines of the completed work and vertically from the foundation elevation to the bottom of the completed excavation.

   c. For pipe culverts, the volume of Culvert Excavation (Unclassified) measured will extend vertically between the normal ground surface and the bottom of the excavation for the pipe, as approved, and horizontally to not beyond two vertical planes separated by a horizontal distance equal to the outside diameter of the pipe plus 3 feet.

   d. Where rock removal is necessary to prepare a satisfactory bed for pipe culverts, the quantity removed will be measured to a

depth of 6 inches below the bed of the pipe, as approved. No allowance will be made for the material used in backfilling, except bedding material when specified.

e. The volume of Dry Excavation (Bridges), Wet Excavation (Bridges), Rock Excavation (Bridges), and Bridge Excavation (Unclassified) measured will extend vertically between the normal ground surface and the bottom of the excavation as approved, and horizontally to the vertical planes located 18 inches outside of the neat lines of the section of the structure at foundation elevation. Where a concrete seal is used, the limits of excavation will not extend beyond the neat lines of the concrete seal, as specified or as directed by the Engineer.

f. For excavation necessary to form struts, diaphragms, beams, and similar features, the volume measured will extend vertically between the normal ground surface and a horizontal plane located 12 inches below the members, and horizontally to the vertical planes located 18 inches beyond the limits of the members.

4. No increase or decrease in payment will be allowed for changes in amount of excavation due to the shifting of location of structures from that shown on the Plans or for the addition of structures to those shown on the Plans when the Plans do not indicate that direct payment will be made for this excavation. Further, if this area of excavation, namely 18 inches horizontally outside of the neat line of the structure at foundation elevation, overlaps an area in which the excavation is computed on a separate unit price, the excavation in the overlapping area will not be allowed.

5. The Department will measure extra excavation below foundation elevation, as shown on the Plans or as directed by the Engineer, if due to causes not attributable to the Contractor's actions.

   In computing extra depth excavation, the working limits established herein will be adhered to.

6. No allowance will be made for shaping necessary to accommodate the bells of the pipe.

7. The Department will measure Rock Drilling performed as specified in **204.10.A** by the linear foot.

B. Protection of Excavation

1. If items for cofferdams or cribs for individual piers or bents are provided by the Plans, the Department will measure this work in individual lump sum items for the pier or bent designated.

2. If a bid item for sheet piles is provided on the Plans, the Department will measure and pay as specified. If payment for the sheet piles is by the square foot, the Department will measure based on the as-designed sheet pile length to retain and counteract lateral earth forces, plus 1 foot.

C. Bedding and Backfill

1. If payment for bedding is provided on the Plans, the Department will determine the volumes of Class A and Class B bedding based on the theoretical quantity, in cubic yards per foot of pipe, as shown on the Standard Drawings.

2. The Department will measure Backfill Material (Flowable Fill) based on the theoretical quantity in cubic yards, as shown on the Standard Drawings. Measurement will be made along the centerline of the pipe for the width of trench shown on the Plans.

3. Material used to replace approved undercutting for box bridges, box culverts, retaining walls or minor structures, including pipe culverts and sewers, will be paid under the item for Foundation Fill Material, and the measurement will be the same quantity as the approved undercutting it replaces.

The Department will not measure for payment:

1. Materials moved from their original position before being measured by the Engineer;

2. Slides, cave-ins, and excavation extending outside of the workable limits;

3. Removal of foundation material that has bulged due to driving piles;

4. Excavation above the normal ground surface, unless otherwise shown on the Plans;

5. Water and its removal; and

6. Construction and/or removal of cofferdams, cribs, sheet piles, or other protective measures provided to safeguard an excavation, unless otherwise shown on the Plans.

204.13 Basis of Payment

If provided for on the Plans, the Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Culvert Excavation (Unclassified)	Cubic Yard
Dry Excavation (Bridges)	Cubic Yard
Wet Excavation (Bridges)	Cubic Yard
Rock Excavation (Bridges)	Cubic Yard
Bridge Excavation (Unclassified)	Cubic Yard
Extra Depth Structure Excavation and Foundation Preparation	Cubic Yard
Rock Drilling (Bridges)	Linear Foot
Bedding Material (Pipe) Class A	Cubic Yard
Bedding Material (Pipe) Class B	Cubic Yard
Cofferdam	Lump Sum
Foundation Preparation	Lump Sum
Backfill Material (Flowable Fill)	Cubic Yard

Such payment is full compensation for providing all materials, equipment, labor, and incidentals to complete the work as specified, including performing embankment construction, sloping, shaping, dressing, disposal of excess or unsuitable material, and final cleanup.

The Department will pay for Structure Excavation and Foundation Preparation of the various classes based on the volume computed in accordance with **204.12**.

A. Extra Depth Structure Excavation and Foundation Preparation

The Department will pay for Extra Depth Structure Excavation and Foundation Preparation, classified as Culvert Excavation (Unclassified), made necessary by the Engineer establishing the foundation below the elevation shown on the Plans, at the contract unit price per cubic yard for Culvert Excavation (Unclassified).

Extra Depth Structure Excavation and Foundation Preparation for bridges made necessary by the Engineer requiring excavation below the foundation elevation shown on the Plans, will be paid for at the contract price per cubic yard for Dry Excavation (Bridges), Wet Excavation (Bridges), Rock Excavation (Bridges), as classified for the actual quantity in cubic yards, excavated from the designated zone, this zone being between the elevation shown on the Plans and the final approved elevation, as directed by the Engineer, plus the additional percentages for each zone corresponding to the depths lowered below Plan elevation as specified in Table 204.13-1.

Table 204.13-1: Designated Zone for Extra Depth Structure Excavation

Sub-Item Designation	Zone No.	Depth Lowered below Plan Elevation		
		More than (ft)	Additional Not Over (ft)	Percent
None	0	0	4	0
a	1	4	8	50
b	2	8		80

Using Table 204.13-1, the Department will compute the volumes of material for payment under any sub-item based on the depths applicable to each zone between the foundation elevation as shown on the Plans and the final foundation elevation as approved by the Engineer. For example: If the foundation were lowered 7-1/2 feet below the foundation elevation shown on the Plans, the Department will compute the volume for the sub-item for a depth of 3-1/2 feet and multiplied by the contract unit price for the class of material excavated plus 50%. The volume of material down to a level 4 feet below the foundation elevation shown on the Plans will be paid for at the contract unit price for the class of material excavated.

B. Cofferdams or Cribs

If items for cofferdams or cribs have been provided for and installed for a designated pier or bent, the lump sum item is full compensation for the furnishing and installation of all material, maintenance, removal, and satisfactory cleanup of the area, and for all tools, equipment, labor, and incidentals necessary to complete the work. Concrete seal shall also be included, except when otherwise shown on the Plans, in which case, measurement and payment for concrete foundation seal will be as provided for under **604.30** and **604.31**.

C. Foundation Preparation

1. Unless otherwise shown on the Plans, no direct payment will be made for Foundation Preparation and Backfill.

2. If Foundation Preparation is a separate pay item, the lump sum price is full compensation for the preparation of foundations for all substructures. The cost for cofferdams, shoring, pumping, or seal concrete required to establish the approved footing shall be incidental to the lump sum bid for Foundation Preparation, except payment will be made at 40% of the price bid for the footing concrete when approved by the Engineer:

    a. For leveling placed within the neat lines of the bottom of the footing, where permitted, and

    b. For additional seal concrete required by changes directed by the Engineer. Payment will be made only for the additional seal concrete placed within vertical planes located 18 inches horizontally outside of the neat lines of the bottom of the footing. No payment of seal concrete will be made for any depth the seal is embedded in sound material below the elevation of the bottom of the pier footing as shown on the Plans to allow placement of an adequate seal.

3. The Department will not allow a percentage increase for extra depth excavation required for the foundation preparation.

4. Unless otherwise provided, the Department will not pay for the sinking of test holes to test foundations.

D. Backfill Material (Flowable Fill)

Payment for Flowable Fill as backfill material for pipe will be included in the unit price paid for pipe unless otherwise shown on the Plans.

E. Bedding Material

Payment for Type A and Type B backfill and bedding material will be included in the unit price paid for pipe unless otherwise shown on the Plans.

The Department will not pay for: material moved before it has been measured by the Engineer; material specified to be moved under **203**; slides or cave-ins occurring outside of the working limits specified in **204.08** and **204.10**; material excavated outside of said working limits; material excavated, even though within the said working limits, below foundation elevation, as indicated or directed, and made necessary on account of the construction methods of the Contractor, or its failure to provide sufficient or proper protection; presplitting of rock; material excavated below foundation when shooting; bulged material caused by driving piles in a foundation; water and its removal; and in general, material moved which would have been unnecessary to move to complete the structure in accordance with the Plans, these Specifications, or the directions of the Engineer.

SECTION 205 – EMBANKMENTS

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DESCRIPTION

205.01 Description

This work consists of constructing roadway embankments, including preparing the area upon which they are to be placed; constructing dikes within or outside the right-of-way; placing and compacting approved material within roadway areas where unsuitable material has been removed; and placing and compacting embankment material in holes, pits, and other depressions within the roadway area.

MATERIALS

205.02 Materials

For embankment and backfill, only use approved materials, consisting of Road and Drainage Excavation, Channel Excavation, and Borrow Excavation material as specified in **203**, or excess material as specified in **204**.

CONSTRUCTION REQUIREMENTS

205.03 Preparation of Embankment Areas

Before beginning embankment construction in any area, complete Clearing and Grubbing, Removal of Structures and Obstructions, and installation of preliminary erosion control measures according to the approved SWPPP as specified in **201**, **202**, and **209** respectively.

Address both natural and created steep slope areas as required in the TN Construction General Permit. Maintain and stabilize steep slopes according to the TN Construction General Permit and all applicable environmental permits.

Remove snow, ice, and mud before placing embankment materials on the ground. Do not place embankment materials on top of ground surfaces and existing embankment layers that are frozen.

Fill all depressions or holes below the natural ground surface, whether caused by grubbing or otherwise, with suitable material and compact to the ground surface before starting embankment construction.

Unless otherwise shown on the Plans or specified in the Special Provisions, if constructing embankment of less than 3 feet below subgrade:

1. Remove all sod and vegetable matter from the surface.

2. Remove unsuitable material and replace with suitable material.

3. Break up the cleared surface by plowing, scarifying, or stripping to a minimum depth of 6 inches, and then re-compact this area.

4. Cultivate sod not required to be removed before constructing the embankment.

5. If a compacted road surface containing granular materials lies within 3 feet of the subgrade, scarify the old road surface to a depth of at least 6 inches, and then re-compact the scarified material.

Remove and dispose of concrete pavement, parking strip, and base, all with or without bituminous overlay, concrete curb and gutter, sidewalk,

driveways, and similar features as specified in **202.06** or as otherwise directed by the Engineer.

When placing embankment material on or against existing slopes that are steeper than 4:1, cut benches into the existing slope while bringing up the new embankment material in layers. Cut each bench of sufficient width to accommodate the operation of placing and compacting equipment. Begin each successive cut at the intersection of the original ground and the vertical side of the previous cut. Re-compact the cut material along with the new embankment material at no additional cost to the Department.

Before placing embankment material on a structure or any unit of a structure, ensure that the surrounding backfill has been completed and thoroughly compacted to ground surface.

205.04 Formation of Embankments

Do not incorporate or bury any perishable materials, such as brush, hedge, roots, stumps, and parts of trees, in the embankments. Do not place rock, broken concrete, or other solid objects in embankments areas where piling will be installed.

Construct embankments so as to provide adequate surface drainage at all times. If roadway embankment materials consist predominantly of soil, place the material in horizontal layers not to exceed 10 inches in loose thickness, and compact each layer to a density not less than 95% of maximum density. Unless otherwise specified, compact the top 6 inches of the roadbed in both cut and fill sections to 100% of maximum density.

The Engineer will determine maximum density and optimum moisture according to AASHTO T 99. For material with less than 5% retained on a No. 4 sieve, method A with 4-inch mold will be used. For material with more than 5% retained on a No. 4 sieve but less than 50% retained on a 3/4-inch sieve, Method D with corrections according to AASHTO T 224 will be used.

Use the correction on soils containing less than 50% plus 3/4-inch material.

Determine the density of the soil in place according to an approved AASHTO method. Compact each embankment layer to the required density, and obtain the Engineer's approval before placing material for the next succeeding layer. Keep placing and compacting areas separate.

If the Contract includes the placement of base stone or other components of a pavement structure upon the subgrade, compact the top 6 inches in both cut and fill sections to a density equal to 100% of the maximum density as specified in **207.04**.

When constructing embankment across low swampy ground that will not support earth moving equipment, construct the lower part of the fill in a uniformly distributed layer of a thickness not greater than necessary to support the hauling equipment while placing subsequent layers. Construct the embankment full width unless otherwise shown on the Plans or approved by the Engineer. The Engineer will waive the density requirement for such a lift, but the moisture content of the material used shall not exceed the optimum moisture range for 95% density for that material. Comply with the maximum thickness and minimum density requirements for all succeeding layers of the embankment.

When a minimum of 95% of maximum density is required, ensure that the moisture content of the material being compacted meets both of the following conditions:

1. The moisture content shall be within the range of values at which 95% of the maximum density can be obtained as indicated by the moisture-density relationship curve; and

2. The moisture content shall not exceed the optimum moisture content to the extent that the material pumps under loads applied by the construction equipment.

Even if the required density is achieved and the moisture content is in range, if pumping occurs, remove the affected sections.

When 100% of maximum density is required, the moisture content of the material being compacted shall meet condition (2) above and shall not vary from the optimum moisture content by more than ±3%.

Aerate the material, or distribute and incorporate water uniformly into the material, as necessary, to control the moisture content within the applicable limits.

If the excavated material consists predominantly of rock, the following shall apply:

A. Definition of Material

If deemed necessary by the Engineer, the Contractor shall conduct test or tests with a 60,000-pound static tamping foot roller (costs to be included in other items) to determine whether the material is degradable or non-degradable. Consider material that readily breaks down under three passes of the 60,000-pound static tamping foot roller as degradable.

B. Non-Degradable Rock

If sound, non-degradable rock is encountered in the unclassified excavation, the Engineer may require the Contractor to provide a mechanical means for separating the sound rock from degradable rock and other soils. The Engineer may allow the use of sound, non-degradable rock in the backfilling of benches, lower and outside portions of embankments, rock buttresses, or other areas.

If the material for embankments consists of sound, non-degradable rock of a size that makes placing the material in 10-inch layers impracticable, place the material in layers no thicker than 3 feet. Do not use rock fragments greater than 2 feet in maximum dimension. With the Engineer's approval, the Contractor may place occasional individual rocks and boulders not exceeding 4 feet in height in the exterior portions of the embankment next to the slope face. Place such rocks to prevent nesting, and fill the adjacent voids with fine fragments to form a dense and compact mass.

Do not dump rock material into its final position. Place rock by blading or dozing in a manner that will minimize voids, pockets, and bridging. Ensure that each layer is leveled the full width of the embankment. Rolling is not required if the rock embankment consists of sound, non-degradable material placed in greater than 10-inch layers.

C. Degradable Rock

Compact degradable rock for use in embankment with an approved vibratory tamping-foot roller in conjunction with a static tamping-foot roller. The minimum weight for the static tamping-foot roller shall be 60,000 pounds. The minimum compaction effort, as rated by the manufacturer, for the vibratory tamping-foot roller shall be 55,000 pounds. Submit roller specifications to the Engineer for approval before use.

Place degradable rock in 10-inch maximum loose lifts, and provide a minimum of three passes with the static roller and two passes with the vibratory roller. The Engineer may direct additional passes with either or both rollers until satisfactory breakdown and compaction is accomplished. Do not place degradable rock in the top 5 feet of an embankment unless approved by the Engineer.

If embankment composed of degradable rock does not contain sufficient moisture to compact properly, the Engineer will require the Contractor to apply water in sufficient quantities to achieve the approximate optimum moisture for the particular material involved. Uniformly mix the added water with the material for the entire depth of the lift by blading, discing, or other approved methods.

D. Combination of Degradable and Non-Degradable Rock

Do not blend or combine degradable rock and non-degradable rock in a common lift without the Engineer's written approval.

If approved, place embankment material consisting of a mixture of degradable rock and non-degradable rock, or rock and soil, in layers not exceeding 10 inches in thickness unless otherwise directed by the Engineer. If the combined material is predominantly sound, non-degradable rock with fragments thicker than 10 inches, the Engineer may increase the layer thickness to be consistent with the size of the material, not to exceed 3 feet. Place the mixture by blading or dozing in a manner that will minimize voids, pockets, and bridging. Compact the mixture with suitable compaction equipment as defined in **205.04.A**, and apply water to facilitate compaction as directed by the Engineer. Uniformly mix the added water with the material for the entire depth of the lift by blading, discing, or other approved methods.

E. Density Requirements

Density requirements will not apply to portions of embankments constructed of materials that cannot be tested by approved methods.

When the Plans require Solid Rock Fill, the material shall consist of sound, non-degradable rock (granite, gneiss, limestone, or other approved material). When the material is subjected to five alternations of the sodium sulfate soundness test performed according to AASHTO T 104, the weighted percentage of loss shall not exceed 12. Do not use plastic soil or

shale material. Place Solid Rock Fill as shown on the Plans or as directed by the Engineer.

Construct the roadway through rock fills to the grading line shown on the Plans with an allowable working tolerance of plus 1 to minus 3 inches. Bring up to grade those portions of the roadway that are then below grade with spalls or other suitable granular material that is available from the excavation within the balance. If no such excavation is available, the Engineer may direct the Contractor to use approved base material for bringing the fill to grade, not to exceed the specified 3-inch limit.

If embankment material is to be placed on both sides of a concrete wall or box type structure, bring the material up equally on both sides of the structure.

At the location of abutments, bents, and similar features, construct embankment to the finished grade before starting excavation on the respective section of the substructure, unless otherwise shown on the Plans. If embankment material is to be placed on only one side of abutments, wing walls, piers, and similar features, do not begin construction until the superstructure is in place. Perform compaction operations without causing wedge action or placing excessive pressure against the structure.

205.05 Stability of Embankments and Cut Slopes

Assume responsibility for the stability of all embankments and cut slopes until final acceptance. Replace, at no additional cost to the Department, all portions which, in the Engineer's opinion, have become displaced or damaged due to carelessness or negligence.

205.06 Disposal of Excess or Unsuitable Material

Dispose of excess or unsuitable material as specified in **203.07**.

COMPENSATION

205.07 Method of Measurement

The Department will not measure embankment. The Contractor shall construct embankments under the items described in **203** and **204** that apply to the materials used to construct the embankments.

The Department will measure excavation to bench side-hill slopes for embankment construction in accordance with **203.09.A.2**.

205.08 Basis of Payment

The Department will not directly pay for embankments. The contract unit prices for the materials with which embankments are acceptably constructed is full compensation for all embankment construction, including materials, equipment, labor, and incidentals to complete the work as specified.

If the Contractor encounters pumping of soil despite having achieved the required density and moisture content, the Department will pay for the removal of these sections as Undercutting by the cubic yard in cut sections only. No such payment will be made in fill sections.

If the excavated material consists predominantly of rock, the Department will pay for water required and provided by the Contractor to facilitate compaction at the unit price per M.G. (1,000 gallons) for Water, which price is full compensation for furnishing and applying the water, mixing, labor, and equipment. The Department will consider all other costs associated with the constructing embankment of material consisting predominantly of rock, including providing suitable compaction equipment and separating sound rock from degradable rock and soils, as included in the unit price for Road and Drainage Excavation (Unclassified).

If the Engineer directs the Contractor to use approved base material to bring portions of the roadway that are less than 3 inches below grade up to grade, the Department will measure and pay for the furnishing and placing of such base material in tons under the applicable item in **303.15**. If base material is not a bid item in the Contract, the Contractor shall provide the material under the provisions of **104.02.D**.

If, despite proper construction and protection, damage to the embankments or cut slopes occurs due to unusual natural causes such as cloudbursts, floods, slides or subsidence, the Department will pay for the material used to make the necessary repairs at the contract unit price for the material classification designated by the Engineer to be used for this purpose. The Department will pay for removal of slides in accordance with **203.10**.

SECTION 206 – FINAL DRESSING

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DESCRIPTION

206.01 Description

This work consists of dressing all slopes and areas, including borrow pits and embankments, and generally preparing the Project for final inspection and acceptance. The costs of this work are incidental to other items of construction.

206.02 Reserved

CONSTRUCTION REQUIREMENTS

206.03 Method and Scope of Work

Perform final dressing by hand work and machines to produce a uniform satisfactory finish to all parts of the roadway and other components of the Project. Shape the roadbed, shoulders, ditches, and slopes to within reasonably close conformity to the specified lines, grades, and cross-sections. Dress spoil banks, borrow areas, waste areas, and similar areas according to the manual *Procedures for Providing Offsite Waste and Borrow on TDOT Construction Projects*. Clear rock cuts of all loose fragments, and leave in a neat, safe, and workmanlike condition.

Clean the right-of-way of all weeds, briars, and brushes unless otherwise shown on the Plans. Clear and clean all structures, both old and new, of all brush, drifts, heavy vegetation, sediment, rubbish, obstructions, and other objectionable material.

Perform final dressing before sodding and seeding operations if the Contract includes these construction items.

206.03

Run tracked machines used in dressing slopes up and down slopes as opposed to longitudinally.

SECTION 207 – SUBGRADE CONSTRUCTION AND PREPARATION

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DESCRIPTION

207.01 Description

This work consists of constructing and preparing part or all of the roadbed to a condition suitable for supporting the immediate construction of a base or pavement.

207.02 Reserved

CONSTRUCTION REQUIREMENTS

207.03 Preparing Subgrade

Perform Excavation and Undercutting as specified in **203**.

Where the roadbed is below grade, haul, spread, and compact, as specified in **205**, suitable material in sufficient quantity to bring the roadbed to grade.

Where the roadbed has been seeded for erosion protection or has established vegetative growth, clip the roadbed to remove vegetation and other deleterious material before placing the base or subbase material. Correct

depressions resulting from the removal of deleterious material by hauling, spreading, and compacting suitable material as specified in **205**.

Where subbases are to be constructed on the subgrade, extend the limits of subgrade preparation across the entire section that will receive the subbase course, including the shoulders.

Where forms are required to construct base or pavement, prepare the subgrade 12 inches wider, on each side, than the neat width of the base or pavement.

207.04 Compacting Subgrade

On subgrades that require reworking, remove all vegetation within the limits of subgrade preparation, and dispose of this material as directed by the Engineer before beginning reworking and re-compacting operations.

The density of the finished subgrade shall not be less than 100% of the maximum density. The optimum moisture, maximum density, and density of the soil in place will be determined in accordance with **205.04**. If field tests show failure to meet the density requirement, loosen the subgrade by discing, harrowing, or other approved methods to a depth of not less than 6 inches, then reshape and re-compact the subgrade material as specified in **205.04**. Moisten or aerate the subgrade material as necessary during mixing and compacting to provide optimum moisture content as specified in **205.04**.

Rework, or remove and replace, all soft, yielding material that will not compact readily, and compact the replacement material as specified in **205**.

207.05 Drainage and Protection

Grade the subgrade so as to provide for ready drainage of water from the subgrade. Maintain ditches and drains to provide proper drainage during the construction.

Take all precautions necessary to protect the subgrade from damage. Limit hauling over the finished subgrade to that which is essential for construction purposes.

Smooth ruts or rough places that develop in a completed subgrade and re-compact as necessary.

207.06 Checking Subgrade

Check the lines, cross-sections, and grades of the subgrade as completed to ensure they are in reasonably close conformity with those shown on the Plans for the bottom of subbase, base, or pavement, or with those established by the direction of the Engineer.

Construct the subgrade to the grading line shown on the Plans, with an allowable working tolerance of ±1 inch.

Recheck the subgrade as specified in the respective sections governing construction of the particular type of base and pavement.

207.07 Disposal of Excess or Unsuitable Material

Dispose of excess or unsuitable material as specified in **203.07**.

COMPENSATION

207.08 Method of Measurement

The Department will measure items of construction as follows:

1. Subgrade Construction and Preparation will be measured by the station (100 feet) along the median center-line of the Project for divided sections, and along the center-line of the pavement for 2-lane and other undivided sections, excluding bridges.

2. The volume of excess or additional material moved, or of unsuitable material removed, will be measured in cubic yards by the cross-section method, or if that method is unfeasible, by some other method, with the volume computed for payment in accordance with **109**.

    a. If grading has been performed under a previous Contract, the Department will measure the number of cubic yards of unsuitable material below subgrade elevation, acceptably removed and disposed of, in both cut and fill sections under the item for Road and Drainage Excavation (Unclassified) in accordance with **203.09.A**.

b. If grading is included in the Contract, the Department will measure the number of cubic yards of unsuitable material below subgrade elevation in cut sections, acceptably removed and disposed of, under the item for Undercutting in accordance with **203.09.E**. In the subgrade of embankment sections, the Department will not measure the removal and disposal of excess or unsuitable material for payment.

3. Water required for compaction by the M.G. (1,000 gallons) will be measured using calibrated tanks or distributors, or accurate water meters.

207.09 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Subgrade Construction and Preparation	Station

Payment for Subgrade Construction and Preparation per 100-foot station is full compensation for shaping and compacting the roadbed, all ramps, service roads, approaches, roadside rest areas, and similar features, as shown on the Plans. If the material to be placed or removed does not exceed a depth of 3 inches, this payment also includes the moving or furnishing of all additional material required, or the disposal of excess material. If a depth of 3 inches is exceeded, the Department will pay for the total quantity of material removed or placed at the appropriate contract unit price per cubic yard for Borrow Excavation (Unclassified) or Road and Drainage Excavation (Unclassified), as provided in **203**.

If the Contract includes the construction of the combined grading, drainage, and pavement structure, the Department will consider the construction and preparation of the subgrade as incidental to the construction and preparation of the road, and the material moved will be classified and included in the computation of pay items provided in **203**.

If the Contract provides for the construction of a subbase, base, or pavement on a road that has been graded under a previous contract, and the item for Subgrade Construction and Preparation is included in the Contract, the Department will pay for this item at the contract unit price per 100-foot station. Payment for material moved will be subject to the stipulations set forth above.

Unless otherwise shown on the Plans, the Department will consider clipping of a roadbed that has been seeded as incidental to other items of construction.

The Department will pay for Water applied as directed by the Engineer at the contract unit price per M.G. (1,000 gallons), as provided in **203**.

SECTION 208 – SHOULDERS AND DITCHES

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DESCRIPTION

208.01 Description

This work consists of constructing shoulders and ditches adjacent to both sides of the base or pavement to obtain proper drainage.

MATERIALS

208.02 Materials

The Contractor may obtain material for constructing shoulders by cleaning out side ditches, if approved by the Engineer. Provide additional material, if required, from approved sources.

EQUIPMENT

208.03 Equipment

The Contractor may perform compaction operations using any type roller that will produce the required results.

CONSTRUCTION REQUIREMENTS

208.04 General

While constructing shoulders, protect the surface and edges of pavement. Do not start shoulder work until the pavement has developed effective resistance to damage.

Complete shoulder construction by blading, moistening as may be necessary, and thoroughly compacting. After completion, maintain the shoulders with respect to lines, grades, and cross-sections until final acceptance of the Project.

208.05 Final Cleanup

Perform Final Dressing as specified in **206**.

Dispose of excess or unsuitable material as specified in **203.07**.

Perform final cleanup as specified in **104.10**.

COMPENSATION

208.06 Method of Measurement

The Department will measure:

1. Shoulder and ditch construction by the mile along each respective shoulder and/or ditch constructed or reworked;

2. Material required in excess of that obtained by cleaning out side ditches by taking cross-sections of the approved borrow pit or pits before and after removal of the material; and

3. Water by the M.G. (1,000 gallons) using calibrated tanks or distributors, or accurate water meters.

208.07 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Shoulders and Ditches	Linear Mile

The Department will pay for material required in excess of that obtained by cleaning outside ditches at the contract unit price per cubic yard for Borrow Excavation (Unclassified).

The Department will pay for water applied as directed by the Engineer at the contract unit price per M.G. (1,000 gallons).

SECTION 209 – PROJECT EROSION PREVENTION AND SEDIMENT CONTROL

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DESCRIPTION

209.01 Description

This work consists of implementing temporary and permanent best management practices (BMPs) to prevent erosion and control sediment through the use of structural and non-structural controls.

Implement erosion prevention and sediment control (EPSC) measures during all phases of construction, including at all approved waste and borrow areas. Ensure that all EPSC measures shown on the Stormwater Pollution Prevention Plan (SWPPP) are in place before beginning soil disturbing activities.

Comply with all provisions of the SWPPP, noting that additional EPSC measures beyond those shown in the SWPPP may be needed to maintain compliance with permits.

209.02 Classification

The Department will classify structural and non-structural BMPs according to the manual for *Management of Storm Water Discharges Associated with Construction Activities*.

BMPs are structural and non-structural controls required for the Project. Implement BMPs according to the more restrictive of the TN Construction General Permit, the manual for *Management of Storm Water Discharges Associated with Construction Activities*, the project SWPPP, and Roadway Standard Drawings.

209.03 Reserved

CONSTRUCTION REQUIREMENTS

209.04 Project Review

At the preconstruction conference, discuss with the Engineer the potential problems with implementing EPSC measures due to construction activities, as well as the actions to be taken to prevent such problems. If the Contractor's operations and construction staging differ significantly from the Project SWPPP, propose modifications to the SWPPP, as specified in **209.05**, that do not conflict with the requirements of the TN Construction General Permit, the conditions of any ARAP for the Project, and other environmental permits. Comply with all provisions of the SWPPP during the term of the Contract.

If a waste or borrow area is needed, prepare a Waste and Borrow Plan according to the manual *Procedures for Providing Offsite Waste and Borrow on TDOT Construction Projects*.

209.05 Preconstruction Conference

The Department will hold a preconstruction conference for every project. For sites that have environmental permits, the Department will also hold an environmental preconstruction conference. These conferences may be held jointly or separately, as determined by the Engineer.

At the preconstruction conference, submit for approval a phasing plan that identifies:

1. All areas within the right-of-way designated for clearing and grubbing, grading, bridges and other structures at water courses, paving, and incidental construction activities; and

2. Areas outside the right-of-way that will be disturbed by the construction such as waste and borrow areas (which must have an

approved Waste and Borrow Plan and be properly permitted), haul roads, utilities, and staging areas, and utility work in general.

If the phasing plan requires additional EPSC measures, or modifications to the existing SWPPP, submit these modifications to the Engineer for discussion during the preconstruction conference. The modifications shall incorporate and supplement, as applicable, the basic control devices shown on the Plans to provide acceptable temporary and permanent EPSC measures during all stages of construction as well as to comply with all applicable environmental permit conditions. The modifications shall also include controls for managing and stabilizing natural and created steep slope areas as defined in the TN Construction General Permit. Do not begin work until the Engineer has accepted the erosion prevention and sediment control plan, including the phasing of temporary and permanent erosion control measures. Rejection of all or part of the plan is not a basis for an extension of contract time.

Discuss with the Engineer how utilities will be managed on the Project, specifically whether or not the utilities are within the construction contract. Coordinate a start date for utilities with the Engineer if utility work will begin before the Project start date. Unless approved in advance by the Engineer, utilities that are within the construction contract cannot begin construction on the Project until the Engineer has approved the work.

Update the EPSC plan as work progresses to show changes due to revisions in work schedules or sequence of construction, or when directed by the Engineer. Install additional measures in the field as needed to manage erosion and sediment and to prevent pollutants from discharging into waters of the State or off the Project.

The environmental preconstruction conference will include a review of the Project's environmental permits and all additional environmental commitments required for the Project. This meeting will address the required marking of clearing limits and the marking of sensitive environmental areas in accordance with applicable environmental permits. Discuss potential problems with implementing the requirements of any environmental permits due to construction activities, as well as actions to be taken to prevent conflicts between environmental permits and construction activities.

209.06 Construction Requirements

Mark the disturbed area limits and environmental boundaries in the field before starting construction in each section or portion of the Project. Before or simultaneously with clearing and grubbing operations, install EPSC devices according to the approved SWPPP. Such work may involve the construction of temporary berms, dams, silt fences, sediment basins, lined channels, permanent cut-off ditches, slope drains, or other control devices as necessary to prevent and control erosion.

Do not pump water from cofferdams or other dewatering activities directly into streams. Pump such water into sediment basins, traps, or filter bags, or otherwise adequately treat before discharging. Do not start grading operations until the EPSC devices are in place to the satisfaction of the Engineer. If adequate controls are in place, the Contractor may clear and grub areas to be graded according to the TN Construction General Permit before starting grading operations. Protect stockpiled topsoil or fill material to prevent sediment runoff from contaminating surrounding areas or entering nearby streams. To reduce sediment in runoff, promptly install EPSC structures during all construction phases and maintain these measures until the areas they are serving have been permanently stabilized.

Identify both natural and created steep slope areas as defined in the TN Construction General Permit. Ensure the SWPPP is updated to reflect all steep slope areas. Manage and stabilize steep slopes according to the TN Construction General Permit and other applicable environmental permits.

Stage construction operations so that graded or otherwise disturbed erodible surfaces remain protected as the Work progresses. Once started, complete grading of roadway cuts or embankments as a continuous, viable operation to subgrade elevation, unless otherwise approved in writing by the Engineer. As grading operations progress, perform final dressing, place topsoil, and protect exposed erodible cut or embankment slopes with permanent seeding, sodding, matting, or other acceptable EPSC measures in vertical increments not exceeding 25 feet. Do not allow any portion of these slopes to remain unprotected longer than allowed by the TN Construction General Permit unless the Engineer determines that weather conditions or other special circumstances prevent prompt placement of permanent control measures. Implement temporary erosion control measures as directed by the Engineer.

Perform seeding, sodding, matting, or other acceptable EPSC operations within 48 hours of the occurrence of either of the following:

1. Each 25-foot vertical increment is graded, or
2. Upon suspension or completion of grading operations in a specific area.

The above requirements for progressive erosion prevention and sediment control also apply to graded areas off the right-of-way, such as waste areas, borrow areas, and haul roads. Develop a Borrow and Waste Plan for all waste or borrow areas selected according to the Statewide Storm Water Management Plan and the manual *Procedures for Providing Offsite Waste and Borrow on TDOT Construction Projects*.

Incorporate all permanent EPSC practices into the Project as soon as practicable and in accordance with the TN Construction General Permit. To the extent practicable, coordinate temporary and permanent erosion prevention and sediment control work. Use temporary EPSC features to control erosive conditions before permanent control features can be installed or to temporarily control erosion that develops during construction but which is not associated with permanent control features on the Project. Perform temporary stabilization of disturbed areas according to the TN Construction General Permit.

Where construction activities cross or border areas of depression (i.e., sinkholes without openings or open throats), install and maintain EPSC measures as shown on the Plans and as required by the TN Construction General Permit and all other applicable environmental permits. If construction activities encounter an open throated sinkhole (Class V Injection Well), immediately notify the Engineer and implement the applicable measures as described in the approved SWPPP. Prevent silt or other potential pollutants from entering the sinkhole opening.

Remove temporary EPSC measures when no longer needed or permanent control measures are installed. Any materials removed shall become the property of the Contractor.

Inspect EPSC measures on a regular basis. Remove accumulated sediment and maintain the structural components of the EPSC measures as necessary to ensure that they continue to function properly. Repair EPSC measures damaged by the Contractor's sediment removal operations at no additional cost to the Department. Upon complete removal of sediment traps, special ditches, and similar structures, restore the area upon which they were constructed by placing topsoil, seed, and mulch, or otherwise stabilizing.

If temporary EPSC measures are required due to the Contractor's negligence, carelessness, or failure to install permanent controls as a part of work as scheduled, and are ordered by the Engineer, perform such work at no additional cost to the Department.

If there is a conflict between these requirements, the TN Construction General Permit, and the laws, rules, or regulations of other Federal, State, or local agencies, adhere to the more restrictive laws, rules, or regulations.

209.07 Construction of Structures

Structural controls include, but are not limited to, bonded fiber matrix, riprap, inlet protection, check dams, silt fence, and sediment basins. Install and maintain structural measures according to the manual for Management of Storm Water Discharges Associated with Construction Activities, TN Construction General Permit, and the Roadway Standard Drawings.

A. Sediment Filter Bags

The Contractor may use sediment bags on slope drains, pipe culverts, and box bridges, or for pumping sediment from sediment traps and sediment basins. Perform such work as shown on Plans or as directed by the Engineer.

Provide filter bags consisting of a non-woven geotextile bag resistant to rot, mildew, puncture, and tearing, and that has a minimum seam breaking strength of 200 pounds. The seams shall demonstrate less elongation and deformation than the geotextile fabric. The Division of Materials and Tests will certify the fabric for the Temporary Sediment Filter Bags and place them on the Department's Qualified Products List.

Ensure that each bag has a permanently attached label from the manufacturer designating the bag's maximum allowable flow rate in gallons per minute. Do not allow the flow into the filter bag to exceed the designated flow rate. Connect the filter bag to the pump hose as recommended by the manufacturer. Upon Project completion, remove the sediment filter bag and permanently stabilize the disturbed areas at the dewatering structure location. Dispose of the bag and the sediment contained in the bag as directed by the Engineer.

B. Sandbag Berms and Temporary Plugs

The Contractor may use sandbag berms and temporary plugs for velocity control, runoff management, sediment control, and separating streamflow from work areas. Do not use sandbag measures for filtration, in high concentrated flow areas where the bags may be displaced by flow, and in areas where equipment and/or traffic may damage the bags. Place sandbags so that their ends tightly abut and overlap to direct flow away from bag joints.

Sandbags for the sandbag berms and channel plugs shall be made of durable, weather resistant geotextile, having tight enough pores to retain the bag filler material. Use of burlap is not acceptable for sandbags used in sandbag berms and temporary plugs. Typical bags measure approximately 24 inches x 12 inches x 6 inches. Use clean, non-cohesive sand as fill material for the sandbags.

Where sandbags are used to construct sandbag berms or temporary plugs across a ditch or channel, install the sandbags along a level contour. Turn the sandbags at the ends of the measure upstream.

The Contractor may install sandbag berms in both unpaved and paved ditches and channels. Construct the sandbag berm to be wider than the high water mark of the ditch or channel to prevent undercutting. The center of the sandbag berm shall be lower than either of the edges. For multiple sandbag berms installed in ditches, the maximum spacing between the berms should be such that the toe of the upstream sandbag berm is at the same elevation as the top of the downstream sandbag berm.

To temporarily separate stream flow from work areas, construct sandbag temporary plugs as necessary. Construct temporary plugs so as to prevent leaks between bags.

Remove and replace torn or damaged sandbags to prevent the bag filler material from becoming a stormwater pollutant. Remove any sediment accumulations at sandbags when the sediment accumulation has reached half the original height of the sandbags. If the ends of sandbag structures are breached, place new bags in the breach, and extend the ends of the berm to a higher elevation. If needed, repair the bank damage. If sandbags are undermined, do not repair the sandbags in place as additional undermining may occur. Move the sandbags downstream of the damaged location.

Upon Project completion, remove all sandbags and permanently stabilize disturbed areas underlying the sandbags with measures such as permanent seed and mulch.

C. Flocculants

Furnish and apply flocculant materials to control erosion on disturbed areas and for use with sediment control devices to reduce turbidity from stormwater runoff.

1. Equipment. If using a liquid application system, it may be necessary to pump a surfactant through the delivery system before injecting liquid flocculant and afterwards to prevent clogging of pipes and valves.

After applying flocculant materials, clean all application equipment according to the flocculant manufacturer's recommendations to prevent the formation of dried residue that may impede future equipment performance.

Apply dry flocculant materials with a hand-held fertilizer spreader or a tractor-mounted spreader. If approved by the flocculant manufacturer, the Contractor may mix certain dry flocculants with dry silica sand to aid in spreading.

2. Limitations. Do not apply cationic PAM blends.

Do not apply flocculants directly to streams, wetlands, or other natural water resources; to sediment ponds; or to slopes that produce runoff directly into a stream, wetland, or other natural water resource. Apply flocculants so that all flocculant-applied runoff flows into a sediment trap, sediment pond, or series of multiple sediment-control BMPs prior to discharge from the site. Always use flocculants for both erosion and sediment control in conjunction with approved stormwater BMPs, as shown on the Standard Drawings.

Perform dry flocculant applications in dry weather conditions with light winds. Do not apply anionic PAM during rainfall or onto saturated soils.

Do not apply flocculants over snow-covered surfaces or over surfaces of pure sand or gravel with no fines.

Apply flocculants at least 60 feet from any stream, wetland, or other natural water resource located on or adjacent to the construction site.

Do not apply emulsion forms of coagulant/flocculants directly to stormwater runoff or to streams, wetlands, or other water resources due to surfactant toxicity. Emulsions may only be used to prepare liquid flocculants specifically used for erosion control applications, such as soil binders and tackifiers.

3. **Preparation of Treatment Areas.** Before using flocculants, obtain and test site-specific soil samples to identify the optimum flocculant blends to use for effectiveness. Obtain soil samples from each soil horizon to be accessed during excavation.

4. **Application Requirements.** Use flocculants in conjunction with other BMPs (with the bulk of structural sediment-control BMPs, including sediment ponds, positioned down slope of the flocculant-application areas) to increase flocculant performance. Direct stormwater runoff from flocculant-treated soils to pass through a series of sediment control BMPs prior to discharge to surface waters, with flow passing through a minimum of three enhanced rock check dams and a silt trap. It is preferable that runoff from flocculant-treated areas be directed into a sediment pond.

   Store flocculant materials in covered areas. Many flocculants demonstrate a decrease in effectiveness after exposure to sunlight and air. Anionic PAM loses its effectiveness within three months after exposure to sunlight and air. Anionic PAM as well as certain other flocculant materials, when combined with water, become very slippery and can produce a safety hazard. Take care to prevent spills of flocculants, in liquid, emulsion, or powder form, onto paved surfaces.

   Application of flocculants will be most effective when applied as follows:

   1. During rough grading operations;

   2. On stockpiles and borrow areas;

   3. Temporary haul roads before placement of crushed rock surface;

4. Compacted soil road base;

5. After final grading and before paving and/or final seeding;

6. Along the interior surface area of ditches;

7. Sites where work has been temporarily suspended (e.g., winter shutdown), and

8. Areas that will be mulched.

The use of a visible tracer or colorant to visibly track flocculant application is recommended.

For liquid applications of flocculants, use source water for mixing with a low turbidity (20 NTUs or less).

For turbidity reduction within sediment ponds, apply flocculants to conveyance ditches above the pond that discharge into the pond.

For dewatering and suspended solids removal of turbid pooled water within pipe tranches, silt traps, or other areas, flocculants may be introduced, in either liquid or solid forms, into the turbid water during pumping/evacuation of the pooled water, with the discharge either pumped through a filter bag or jute-lined treatment ditch prior to ultimate discharge. Strictly adhere to the application rates as given in this specification for turbidity reduction for anionic PAM, and as given by the manufacturers' requirements for other types of flocculants, during dewatering.

a. Anionic Polyacrylamide. Before using any flocculant, submit the flocculant manufacturer's written application, storage, and mixing requirements and specifications to the Engineer.

Store, handle, mix, and apply anionic PAM in strict accordance with the flocculant manufacturer's recommendations and in strict compliance with OSHA Material Safety Data Sheet requirements and all applicable Federal, State, and local regulations. Use proper personal protective equipment when handling the flocculant per industry, manufacturer, State, and Federal regulations.

Do not exceed the specified maximum application rates for anionic PAM. Applying additional PAM beyond the rates specified will not improve the effectiveness of PAM but could present toxicity issues to receiving streams down gradient of the PAM application zone.

(1) For Erosion Control Applications on Sloped Areas

a) For hydroseeding applications, add anionic PAM as the last component to the hydroseeding mixture. When mixing, never add water to anionic PAM. Add PAM at a slow rate to water. Mixing of anionic PAM for hydroseeding shall include agitation of the PAM/water mixture. Apply using a method that will ensure uniform flocculant coverage over the target application area.

b) Never use anionic PAM as the sole erosion control method for slopes; accompany slope applications of PAM with mulching.

c) For PAM tackifiers, dissolve dry PAM with a known quantity of clean water in a container for several hours (preferably overnight). Apply PAM using a hydro-mulch machine at a rate ranging from 0.5 pounds to 1.0 pound (maximum) per 1,000 gallons of water per acre of application area.

d) For soil binder applications, dissolve pre-measured dry PAM with a known quantity of clean water in a container for several hours (preferably overnight.) Apply PAM at a rate ranging from 2/3 pounds to 1 pound (maximum) per 1,000 gallons of water per acre of bare soil.

e) Mix emulsion batches according to the recommendations of the flocculant manufacturer to determine the proper product type and application rate to meet site-specific requirements. Apply using a method that will ensure uniform coverage over the target application area.

f) When using an emulsion form of anionic PAM to slopes, apply no greater than 1.5 gallons emulsion per acre per event. Solution mixtures shall be 1.5 gallons (maximum) anionic PAM emulsion per 3,000 gallons of water. Do not use water volumes that are less than 3,000 gallons of water due to increased viscosity issues.

g) Spray the anionic PAM/water mixture uniformly across the dry soil slope until completely wetted.

h) For dry anionic PAM applications for erosion control, apply anionic PAM as a powder at the following rates:

- For slopes less than 25%, apply at a maximum rate of 10 pounds per acre

- For slopes greater than or equal to 25%, apply at a maximum rate of 20 pounds per acre

i) Reapply liquid anionic PAM for erosion control on actively worked areas after a 48-hour period.

j) Do not apply liquid anionic PAM to the same slope area more than once in a 48-hour period and no more than seven times in a 30-day period.

k) For inactive slope areas where anionic PAM has been applied, reapply once every two months.

l) Anionic PAM applications (dry or liquid) shall not exceed 200 pounds per acre per year.

(2) For Turbidity Reduction within Ditches:

a) If possible, apply flocculant as erosion control in the watershed above the treatment ditches in conjunction with the application of flocculants within treatment ditches for turbidity control.

b) Line the surface area of stormwater ditches, as well as the surface area of ditch check dams, with jute mesh.

c) Apply dry powder anionic PAM over the jute mesh at a rate of 0.25 pounds to 0.5 pounds per 1,000 square feet of ditch surface area.

d) Reapply dry powder anionic PAM to jute mesh in ditches every three to five storm events. Dry anionic PAM application shall not exceed 4.6 pounds per 1,000 square feet per year.

e) Ensure anionic PAM bricks/logs are of appropriate size, shape, and number to deliver the appropriate dosage to the water within the conveyance. Obtain brick/log dissolution rates and dosages from the flocculant manufacturer.

f) Locate anionic PAM bricks/logs in a shaded, preferably moist, installation zone during application.

g) Place anionic PAM bricks/logs near the main flow area of the ditch, at an appropriate distance above sediment ponds or traps to maximize mixing and flocculation. Refer to the manufacturer's guidance for flocculant mixing time and block/log spacing configurations.

h) Install one anionic PAM brick/log for every 65 to 70 gallons per minute of flow to be treated, unless otherwise specified by the flocculant manufacturer.

i) Unless otherwise specified by the flocculant manufacturer, anionic PAM bricks/logs are estimated to treat, on average, 475,000 to 550,000 total gallons of flow volume.

j) Install stakes, mesh bags, cages, and other mechanisms to anchor bricks/logs in place to provide stability during flows and to maximize exposure of the brick/log surface area to flows.

k) Replace anionic PAM bricks/logs at least every 3 to 4 months or earlier if bricks/logs have excessive sediment/debris deposition on the outer brick/log surface area or excessive degradation of brick/log mass.

b. Miscellaneous Coagulants/Flocculants. Miscellaneous flocculant materials shall include all other flocculants that are not polyacylamide blends and that have been pre-approved for use on Department projects through the Materials and Testing Division.

Before using any flocculant, submit the manufacturer's written application, storage, and mixing requirements and specifications to the Engineer.

Store, handle, mix, and apply flocculants in strict accordance with the flocculant manufacturer's recommendations and in strict compliance with OSHA Material Safety Data Sheet requirements and all applicable Federal, State, and local regulations. Use proper personal protective equipment when handling the flocculant per industry, manufacturer, State, and Federal regulations.

Do not exceed the manufacturer's specified application rates for flocculants.

For erosion and sediment control applications for sloped areas and ditches:

1. Strictly follow the manufacturer's requirements for application mixtures and rates.

2. With hydroseeding applications, mix flocculants according to the manufacturer's written recommendations.

3. Do not use flocculants as the sole erosion control method for slopes; accompany slope applications of flocculants with mulching. Use flocculant for turbidity reduction in ditches in conjunction with other structural sediment-control BMPs.

4. Re-application frequency and rates shall strictly follow the manufacturer's written recommendations, as provided to the Department and the Contractor.

5. Store flocculants according to the manufacturer's written requirements, as provided to the Department and the Contractor.

5. Documentation and Maintenance. Flocculants will enhance the deposition of soil solids in downstream ditches, pipes, and ponds. Inspect these hydraulic structures regularly, and routinely remove solids from these structures to ensure optimization of performance.

Provide suitable means for storing and protecting flocculants against moisture and sunlight.

Department field personnel will maintain records of all flocculant applications including the following information:

a) Date, time, and specific location of application;

b) Rates of application;

c) Method of application;

d) Weather conditions, and

e) Type of flocculant applied including manufacturer name and product name.

6. Final Cleanup. Clean liquid or dry flocculant spills according to the manufacturer's requirements. Thoroughly rinse flocculant mixing and application equipment with water to prevent residue formation. The Contractor may apply rinse residues to exposed slopes for erosion control. Keep the amount of unused flocculant mixtures to a minimum. Dispose of excess flocculant material in compliance with Federal, State, and local environmental regulations. Do not dispose of excess material within stormwater conveyances, sewers, or streams.

Where temporary erosion prevention and sediment control or pollution prevention work is acceptably performed and failure of all or any part of the

system occurs but is not attributed to the Contractor's negligence, carelessness, or failure to install permanent controls and falls within the specifications for a work item that has a contract price, the Department will pay for units of work at the proper contract prices except as noted below. Should the temporary EPSC work not be comparable to the project work under the applicable contract items, the Department will direct the Contractor to perform the work on a force account basis, or by agreed unit prices as specified in **109.04**.

Except as noted below, the Department may pay the Contractor to replace temporary EPSC measures installed according to the Plans or as approved by the Engineer provided such devices are no longer effective due to deterioration or functional incapacity that is not attributable to improper installation, lack of reasonable maintenance, or failure of the Contractor to pursue timely installation of permanent control devices according to the Plans and Specifications or as directed by the Engineer.

Unless provided for on the Plans, the Department will not directly pay for temporary and permanent EPSC measures in disturbed areas outside the right-of-way, such as borrow areas, waste areas, and haul roads, unless the borrow areas or waste areas are provided for by the Department, and except for permanent Seeding (with Mulch) on borrow areas and waste areas within the limitations specified in **203.04.E** and **203.07**, respectively. Where the Plans show separate quantities for erosion prevention and sediment control or pollution prevention items to be used outside the right-of-way in connection with waste areas, borrow areas or other project related construction, the Department will pay for the items used and accepted up to the plan quantities; but the cost of any overruns in these items, or the cost of any additional items required for erosion prevention and sediment control or pollution prevention off the right-of-way, shall be borne by the Contractor unless prior written approval is received from the Engineer.

If the Contractor fails to control project related erosion or the discharge of pollutants, either on or off the right-of-way, the Engineer may withhold payment of future progress estimates until the Contractor has satisfactorily performed the necessary corrective measures. If deemed necessary, the Engineer may employ outside assistance or use Department forces to provide the needed protective measures, and will charge all incurred direct costs plus project engineering costs to the Contractor by appropriate deductions from the Contractor's monthly progress estimate.

COMPENSATION

209.08 Method of Measurement

The Department will measure EPSC measures according to the appropriate Standard Drawing or as specified below.

The Department will measure:

1. Temporary seeding and mulching operations in accordance with the appropriate provisions of **801.09**.

2. Seeding (without Mulch) and Crown vetch mixture (without Mulch) per unit.

3. Accepted quantities of Road and Drainage Excavation by the cubic yard.

4. Sediment removal and disposal for maintaining erosion prevention and sediment control measures by the cubic yard.

5. Sand bags by the square foot area of berm face.

6. Flocculants used for turbidity reduction by the actual weight in pounds of flocculant materials applied, or, for brick or log forms of flocculant material, by the unit, per each.

7. Flocculants used as either a soil binder or tackifier for erosion control applications by the acre.

209.09 Basis of Payment

The Department will not make separate payment for Non-Structural BMPs.

The Department will pay for accepted quantities of EPSC measures based on the item numbers and measurement and payment information provided on the Standard Drawings.

Unless otherwise stated on the corresponding Standard Drawings, payment for EPSC measures is full compensation for all materials and labor necessary to construct, maintain, and remove the measures.

For catch basin filter assemblies, structure maintenance including cleaning to prevent clogging is included in the contract unit price for the structure. The Department will not directly pay for sediment removal and disposal for maintaining these assemblies.

The Department will pay for Seeding (with Mulch), Seeding (without Mulch), Temporary Seeding (with Mulch) Crown vetch mixture (without Mulch), and Mulch items in accordance with **801.10**.

The Department will pay for accepted quantities of Road and Drainage Excavation at the contract unit price per cubic yard.

Unless otherwise specified, the Department will pay for sediment removal and disposal for maintaining EPSC measures at the contract unit price per cubic yard.

The Department will pay for rock used for inlet and outlet control on EPSC measures at the contract unit price per ton.

The Department will pay for pipe used to construct EPSC measures in accordance with **607.13**.

The Department will pay for concrete used to construct spillways or other sediment control structures in accordance with **703**.

The Department will pay for water used to prepare the seed bed and for maintenance at the contract unit price per M.G. (1,000 gallons) of water.

The Department will pay for sandbags at the contract unit price per bag.

The Department will pay for accepted quantities of flocculants at the contract unit price. Such payment is full compensation for all equipment, materials, labor, and incidentals necessary to apply the flocculant materials.

The Department will pay for sediment filter bags at the contract unit price for the size bag used. Such payment includes installation and replacement as needed, along with all materials, equipment, tools, labor, and incidentals to complete the work. The Department will pay for removal and disposal of material from bag by the cubic yard at the contract unit price for sediment removal.

PART 3 – BASE AND SUBGRADE TREATMENTS

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DESCRIPTION

302.01 Description

This work consists of treating in-place subgrade material with lime, and includes preparing the existing subgrade, distributing the specified percentage of lime, initial mixing, mellowing, final mixing, compacting, finishing, and curing.

302.02 Reserved

MATERIALS

302.03 Materials

A. Lime

Provide either hydrated lime or quicklime meeting **921.04**.

B. Water

Only use water that is free of injurious quantities of oil, salt, acid, alkali, sugar, vegetable matter, or other detrimental substances.

C. Soil

Use in-place subgrade material, except remove soil that is unsuitable for stabilization and replace it with suitable material.

Before the work is started, the Department will sample the in-place material and perform laboratory testing to determine the percentage of lime required and the appropriate optimum moisture content of the lime-soil mixture according to AASHTO T 99, Method C.

D. Bituminous Material

For use as a curing agent, provide bituminous material as specified in:

PG64-22, 70-22, 76-22, and 82-22 ..... **904.01**
Emulsified Asphalt,
Types allowed for Tack Coat in **403**..... **904.03**

Provide emulsified asphalt, of a type allowed for Tack Coat in **403**, meeting the test requirements specified in Table **904.03-1**.

The Contractor may select the type of bituminous material to use for curing.

EQUIPMENT

302.04 Equipment

A. Distributing Equipment

Provide equipment to distribute the lime uniformly, at the required rate and without excessive loss.

B. Mixers

For final mixing, provide mechanical mixers as specified in **303.05.B**. If stone, gravel, or similar material is encountered in the subgrade in such quantity and size to prohibit the practical use of mechanical mixers, as determined by the Engineer, the Contractor may perform final mixing with disc harrows or other approved equipment. The mixing equipment shall be capable of attaining the degree of pulverization specified in **302.10** and of thoroughly mixing the soil and lime to the full required depth of the loose material.

C. Compaction Equipment

Provide compaction equipment of the size and weight required to obtain the specified density and quality of finished surface.

CONSTRUCTION REQUIREMENTS

302.05 Limitations

Handle and store lime in completely enclosed, moisture resistant containers until immediately before transporting to the site. Store bagged lime in weatherproof buildings with adequate protection from ground dampness.

Do not stabilize areas that will not be covered with the succeeding stage of sub-base or base construction during the same construction season.

Do not apply lime:

1. to frozen subgrade material;
2. if the air temperature in the shade is less than 40 °F;
3. during periods of high winds; and

4. to areas that cannot be mixed and sealed as specified in **302.09** on the same day as application.

Do not leave lime exposed to the open air for a period of 6 hours or more.

Do not allow traffic or equipment on the spread lime other than that required for spreading, watering, or mixing.

302.06 Preparing the Existing Subgrade

Grade and shape the existing roadway in reasonably close conformity with the lines, grades, and cross-sections shown on the Plans or as directed by the Engineer.

Remove all grass turfs and other deleterious substances from the subgrade, and prepare the subgrade as specified in **207.03**.

Correct wet or unstable underlying foundation material, if encountered, as directed by the Engineer.

302.07 Extra Depth Stabilization

If directed by the Engineer, perform extra depth lime stabilization as follows:

1. Blade the overlying material to the sides, and incorporate the lime slurry or, in dry applications, the hydrated lime and any necessary water, into the underlying material at the rate and to the depth specified.

2. Thoroughly mix and compact the lime-soil mixture to obtain the required stability.

3. Moisten the compacted surface, and cover with the previously windrowed subgrade material.

4. Compact the overlying subgrade material, which will serve as the curing medium.

Curing and mellowing periods will not be required for the lime-stabilized underlying material unless otherwise directed by the Engineer.

302.08 Applying Lime

After preparing the subgrade as specified in **302.06**, apply lime using the dry application method for hydrated lime or the slurry application method for either hydrated lime or quicklime. Use the slurry application method unless otherwise shown on the Plans.

A. Dry Application

Spread hydrated lime at the required rate, using an approved spreader that will uniformly distribute the material without excessive loss, or by bag distribution.

B. Slurry Preparation and Application

Mix lime with water in approved agitating equipment, and apply to the roadway as a thin water suspension or slurry through approved distributing equipment. The distributing equipment shall be equipped to continuously agitate the mixture from the mixing site until applied on the roadbed. Proportion the mixture so that the dry solids content is at least 30% by weight.

In preparing, transporting, distributing, and mixing slurry with the soil, do not cause injury, damage, discomfort, or inconvenience to individuals or private property.

302.09 Initial Mixing and Mellowing

In dry applications, immediately after applying the hydrated lime, scarify the course, if necessary, and mix to the required depth, width, and cross-section(s).

In slurry applications, before applying the lime slurry, scarify or partially pulverize with approved mixing equipment the full width of the course to be treated, as directed by the Engineer, to the depth required for stabilization. Perform successive passes over a measured section until the specified percentage of lime has been distributed. After each successive pass, incorporate the slurry into the soil with approved mixing equipment.

Incorporate lime into the soil to the depth needed to provide a finished course of lime-treated material conforming to the specified thickness and surface requirements.

Continue mixing, and applying water as necessary, until a homogeneous mixture of soil, lime, and water is obtained. During this initial mixing operation, add the quantity of water needed for the moisture content of the mixture to reach 5% above its optimum moisture content, plus or minus 3%, unless otherwise directed by the Engineer.

If applying the lime as a slurry, ensure that the water added with the slurry does not cause the moisture content of the lime-soil mixture to exceed the above tolerance.

After completing mixing operations, reshape the treated course to the approximate lines, grades, and cross-sections, and seal with a pneumatic-tire roller, and other approved equipment as necessary, and allow the treated course to mellow for 2 to 7 days as directed by the Engineer. During the mellowing period, maintain the entire surface of the treated course in a moist condition.

302.10 Final Mixing

After the required mellowing period, reshape and grade the initially mixed material to the required lines, grades, and cross-sections.

Thoroughly mix the previously mixed material with approved mixers while adding water as necessary.

Continue mixing until 100% of the material, except for gravel and stone, will pass a 1-inch sieve, and 60% by dry weight will pass the No. 4 sieve.

The quantity of water added shall be such that at the end of the final mixing and during compaction and finishing operations the percentage of moisture in the mixture and the unpulverized soil lumps will not vary more than plus or minus 3% from the specified optimum moisture of the lime-soil mixture.

302.11 Compaction and Finishing

Immediately after completing the final mixing, blade the material to uniform thickness and shape, and start compaction operations. Use sheepsfoot rollers to compact the material in a continuous operation until the entire depth of the lime-soil mixture is uniformly compacted to the required density. The Contractor may remove the sheepsfoot rollers when a surface mulch not exceeding 1 inch remains. Lightly scarify the resulting surface and shape to the required lines, grades, and cross-sections within the

tolerances specified in **302.13**. Perform final rolling with the roller specified by the Engineer.

The completed lime stabilized subgrade shall be smooth, dense, well bonded, unyielding, and free of cracks or loose material.

Compact the lime-soil mixture in layers as shown on the Plans. The Department will determine the maximum density and optimum moisture content of the lime-soil mixture according to AASHTO T 99. The sample used to determine the maximum density and optimum moisture content will be representative field samples of the lime-soil mixture that have undergone the same treatment as the lime treated subgrade being tested.

For density testing purposes, the Department will divide the completed subgrade treatment into lots of approximately 10,000 square yards, and will perform five density tests on each lot. The average dry density of each lot shall be not less than 95% of maximum density, and no individual test shall be less than 92% of maximum density. At the beginning of the Project or as necessary, smaller lots may be considered to evaluate rolling procedures or for other reasons as approved or directed by the Engineer.

Immediately scarify, moisten (if required), rework, and compact to the required density all areas that do not meet density requirements at no additional cost to the Department.

302.12 Curing

After finishing the lime-treated subgrade as specified in **302.11**, seal the surface by applying one of the bituminous materials specified in **302.03.D** using a pressure distributor at the rate of 0.10 to 0.25 gallons per square yard, as directed by the Engineer or as shown on the Plans. Heat or otherwise prepare the bituminous material to ensure uniform distribution and apply as soon as possible.

302.13 Tolerances and Reconstruction

The Department will determine the thickness of the completed lime-treated subgrade by measuring test holes at random locations at intervals not to exceed 500 feet. The measured thickness at the locations shall not deviate from that shown on the Plans by more than plus 1-1/2 inches or minus 1 inch.

Immediately reconstruct areas of lime-treated subgrade that do not meet thickness requirements. For areas having a thickness greater than that allowed, add sufficient lime to correct the deficiency in lime content. Perform reconstruction, including adding lime, to correct the thickness deviation at no cost to the Department.

As directed by the Engineer, repair areas of lime-treated subgrade that become unstable or that lose the required density or surface finish. Use additional lime and water if and as directed.

Limit hauling over the treated subgrade to the minimum amount necessary to construct the overlying base or sub-base.

When at least one course of base or sub-base has been constructed upon the treated subgrade, the Contractor may resume hauling, provided the layer or layers of base or sub-base are constructed and maintained as specified in **303.10** and **303.11**.

COMPENSATION

302.14 Method of Measurement

A. Lime

The Department will measure Lime by the ton. Quantities and percentages of lime shown on the Plans are based on preliminary soil investigations and dry laboratory sample tests using hydrated lime. The Engineer will establish the actual application rate from dry density tests conducted just before the start of stabilization work. For quicklime, the Department will determine the accepted quantity by converting the quicklime to an equivalent quantity of hydrated lime as follows:

$$\mathrm{EHL} = 1.32\ \mathrm{QL}\left[1 - \frac{\mathrm{I}}{100}\right]$$

Where:

EHL = Equivalent amount of hydrated lime in tons
QL = Tons of quicklime accepted
I = Percent of impurities in the quicklime

The Department will deduct for quantities of lime that have been wasted or not actually used in the work.

If sacked lime is used, the Department will use the net weight as packed by the manufacturer for measurement.

B. Processing of Subgrade Treatment (Lime)

The Department will determine the area processed by the square yards of treated subgrade, as computed using the length measured at the surface of the treated subgrade and the width shown on the Plans or designated by the Engineer.

C. Extra Depth Stabilization

1. Direction Application Method. The Department will classify processing performed using the Direct Application Method, as specified in **302.07**, as Subgrade Treatment, and will measure this work for payment as follows:

a. If the thickness of the layers processed is equal to or greater than the Plan thickness for normal stabilization, the Department will measure processing by the square yards of each extra depth layer processed.

b. If the thickness of the layers processed is less than the Plan thickness for normal stabilization, the Department will measure the area in square yards of each extra depth layer processed and will adjust this area to determine the quantity for payment by multiplying the number of square yards processed by the thickness of the layer and dividing by the Plan thickness for normal stabilization. To determine the area of extra depth layers, the Department will measure the length and width used in accordance with **302.14.B**.

2. Drill-Lime Method. The Department will measure drilling necessary to complete Extra Depth Stabilization by the total quantity in linear feet of all holes drilled, from either the finished subgrade or from the top of base, as the case may be, to the bottom of the drilled holes.

D. Water

The Department will measure water by the M.G. (1,000 gallons) using calibrated tanks or distributors, or accurate water meters. The quantity measured for payment will be the amount necessary for subgrade preparation, initial mixing, mellowing, final mixing, compacting, finishing, and curing. The Department will not measure water used to prepare or apply slurry.

E. Bituminous Material

The Department will measure in tons the quantity of bituminous material used and accepted.

F. Preparation of Existing Subgrade

The Department will classify and measure the materials moved, furnished, or disposed of to prepare the subgrade in accordance with **302.06** as provided for under **207**.

302.15 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Hydrated Lime	Ton
Bituminous Material	Ton
Soil-Lime Processing	Square Yard
Drilling for Subgrade Treatment	Linear Feet
Water	M.G.

Such payment is full compensation for providing all materials, equipment, labor, and incidentals to complete the work as specified.

The Department will pay for moving, furnishing, or disposing of material under **207** if the Contract is for any of the following:

1. Combined grading, drainage and paving project,

2. Construction of a base and/or pavement on a road that has been graded under a previous Contract, or

3. Base and/or paving project that includes sections of grading.

For Extra Depth Stabilization, the Department will not pay for any shifting of the overlying material; however, the Department will pay for the lime and water used and for the mixing of the underlying material with the lime and water.

If repairs to the lime-treated surface are made necessary by a cause beyond the Contractor's control, the Department will pay for the construction items involved at the contract unit prices.

SECTION 303 – MINERAL AGGREGATE BASE

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DESCRIPTION

303.01 Description

This work consists of furnishing and placing one or more courses of aggregates, and additives if required, on a prepared subgrade.

Mineral aggregates base shall be Type A or Type B, whichever is shown on the Plans and called for in the bid schedule.

MATERIALS

303.02 Aggregate

Depending upon whether the Plans require Type A or Type B base, provide mineral aggregate meeting **903.05**. For Type A base, use aggregate of

Grading D. For Type B base, the Contractor may use aggregate of Grading C or D.

The Engineer will accept aggregate for gradation as follows:

1. When the stationary plant method for mixing is used, the Engineer will accept aggregate immediately after or prior to mixing, based on periodic samples taken from the pugmill output or from the belt feeding the pugmill.

2. When two or more materials are blended on the road using mechanical mixers, the Engineer will accept aggregate after mixing and before compaction, based on samples taken from each layer of base material.

3. For aggregate that does not require blending, the Engineer will accept aggregate at the aggregate production plant, based on samples taken from stockpiles of plant production immediately before delivery to the road.

303.03 Calcium Chloride

Provide calcium chloride meeting **921.02** for Type 1, Type 2 or calcium chloride liquor.

303.04 Sodium Chloride

Provide sodium chloride meeting **921.03**.

303.05 Emulsified Asphalt

Use emulsified asphalt of a type allowed for Prime Coat in **401**, meeting the test requirements specified in **904.03**.

EQUIPMENT

303.06 Equipment

Provide a stationary mixing plant, mechanical road mixer, or motor grader, whichever is applicable to the type of work to be performed, as specified in **303.08**.

A. Stationary Mixing Plant

Provide an approved twin-shaft pugmill capable of producing a constant, uniform mixture. Equip the mixing plant with the following:

1. A suitable truck-loading hopper with a gate that will prevent segregation of the material when dumped into the truck;

2. A spray bar, capable of ensuring an even wetting of the aggregate, mounted at the entrance of or above the pugmill;

3. A meter, valve, or other approved type of regulating device to control the flow of water through the spray bar to maintain a uniform moisture content in the mixture;

4. A separate, quick, and automatically operating on-and-off device to shut the water off instantly when the pugmill stops; and

5. Adjustable mechanical feeders for each size material capable of regulating a constant, uniform flow of material.

B. Mechanical Mixer (for Road Mixing)

Provide a pugmill or rotary type mechanical mixer capable of producing a uniform blend of all materials to the full depth of the course being placed. The mixer may be either self-propelled or trailer-drawn.

C. Compaction Equipment

Provide one or more rollers of a type and sufficient weight to obtain the required density and seal the surface of the base course.

CONSTRUCTION REQUIREMENTS

303.07 General

Construct Mineral Aggregate Base, Type A or Type B, in one or more layers, to the compacted thickness shown on the Plans.

Prepare the subgrade as specified in **205**, **207**, or **302**, whichever is applicable.

Obtain the Engineer's approval of the subgrade before spreading any mineral aggregate. Subgrade that has been previously checked and approved, but subsequently subjected to freezing conditions or prolonged wet weather, shall be rechecked for approval.

Do not spread mineral aggregate on a subgrade that is frozen or contains frost.

Do not haul over any material that has been placed until it has been spread, mixed, shaped and compacted to the required density.

303.08 Mixing

A. Mixing Methods

Unless otherwise specified, mix the base course material, including an additive if shown on the Plans, by one or more of the following three methods:

1. **Stationary Plant Method.** Mix the base course material and water in an approved stationary mixing plant as specified in **303.06.A**. Add sufficient water during the mixing operation to provide a moisture content satisfactory for compacting. If combining materials to meet the grading requirements, blend the materials, as specified in **903.05**, before mixing. Ensure that all material fed into the plant travels the full length of the pugmill.

2. **Road Mix Method (Mechanical Mixer).** After placing the material for each layer of base course through an aggregate spreader or windrow-sizing device, mix the material using approved mechanical mixing machines as specified in **303.06.B**.

   During mixing, add sufficient water to provide a moisture content satisfactory for compacting.

3. **Road Mix Method (Motor Grader).** After depositing and uniformly spreading material for each layer of base course, sprinkle it with just enough water to moisten all particles, but without causing segregation of sizes or softening of the subgrade. Immediately after applying water, thoroughly mix the material by

windrowing and spreading with motor graders until the mixture is uniform throughout.

For Mineral Aggregate Base, Type A, use the stationary plant method. For Mineral Aggregate Base, Type B, requiring the blending of two or more materials, use either the stationary plant method or the road mix method (mechanical mixer), except as provided for in **903.05**. For Mineral Aggregate Base, Type B, requiring additive, use either stationary plant mixing or road mixing.

B. Use of Calcium Chloride and Sodium Chloride

If using calcium chloride, incorporate it in either the solid or liquid form, at the approximate rate of 6 pounds per ton of aggregate, noting that:

- 6 pounds is equivalent to 1.29 gallons 60 °F 32% solution
- 6 pounds is equivalent to 1.02 gallons 60 °F 38% solution

If using sodium chloride, incorporate it at the approximate rate of 5 pounds per ton of aggregate.

For stationary plant mixing, proportion chloride material, in solid form, through a hopper equipped with an approved vibratory feeder and an adjustable opening capable of accurately controlling the flow of material. Proportion calcium chloride liquor using an approved calibrated meter that has a registering capacity capable of indicating the total amount of liquid used during any single day's operation.

For road mixing, add the chloride material to the aggregate at the point in the mixing operation and in the manner directed by the Engineer.

303.09 Spreading

Spread material as follows according to the mix method used:

A. Stationary Plant Mixing

After mixing, transport material to the site for each layer of base while it contains the proper moisture content. Spread the material to the required thickness and cross-section using an approved mechanical spreader.

B. Road Mixing (Mechanical Mixer)

Before mixing, spread material with an approved mechanical spreader that can be adjusted to spread materials in the proper proportions.

C. Road Mixing (Motor Grader)

After thoroughly mixing the aggregate and water, spread the base material while at optimum moisture content in layers of specified thickness and cross-section using approved motor graders.

If the required compacted depth of the base course exceeds 6 inches, construct the base in two or more layers of approximate equal thickness. The maximum compacted thickness of any one layer shall not exceed 6 inches; however, if vibrating or other approved types of special compacting equipment are used, the Contractor may increase the compacted depth of a single base course layer to 8 inches with the Engineer's approval.

In some cases, the Plans may show the base as extending for the full width of the roadbed. In other cases, the edges of the base may be shown as coinciding with the inside edges of the shoulders. In the latter case, place shoulder material to a minimum width of 3 feet before spreading each layer of base material in order to confine the base material and to allow for proper compaction.

The Contractor may spread and mix any base material used for constructing detours, for maintenance of traffic, for backfilling rock cuts, and for capping rock fills as specified in **303.09.C**.

303.10 Shaping and Compaction

A. Final Shaping

Immediately after spreading, shape the base material to the required degree of uniformity and smoothness. Except where using mechanical aggregate spreading equipment to place the base material, use a motor grader to shape each layer before compacting. If the mechanical spreading equipment fails to shape the base material properly, use a motor grader or other approved means to perform final shaping.

B. Compaction

Compact the base material to the required density before any appreciable evaporation of surface moisture occurs. Continuously compact each layer until the minimum density requirement, as specified in **303.10.C.2**, is achieved. The Contractor may use any type of compacting equipment provided the required density is attained.

If, as provided for in **303.10.C.3**, the density requirement does not apply, gradually compact the base material, progressing from the edges of the base to the center, parallel with the center-line of the road. Continue compacting until the base layer has been compacted to its full width as directed by the Engineer. Where lifts of shoulder materials are placed to confine the base material, overlap the initial pass of the compacting equipment with the shoulder to a width of not less than 12 inches.

Construct the surface of each layer so that the aggregates become firmly keyed and a uniform texture is produced. Maintain the surface in this condition until it is covered by the following stage of construction or until final acceptance of the project. Correct irregularities by loosening the material at those places and adding or removing material as required.

Use approved distributors to apply water uniformly over the base materials during compaction in sufficient quantity to allow for proper compaction without causing softening of the underlying subgrade due to excessive water use.

C. Compaction Acceptance

1. **Lot Sizes and Testing.** For density testing purposes, the Department will divide each completed layer into lots of approximately 10,000 square yards, and will average the results of five density tests performed on each lot. Smaller lots may be considered as directed or approved by the Engineer.

2. Density Requirements

a. Type A Base. The average density of each lot of Type A base, unless otherwise specified, shall be not less than 100% of maximum density as determined according to AASHTO T 99, Method D, with no individual test less than 97% of maximum density.

b. Type B Base. The average density of each lot of Type B base, unless otherwise specified, shall be not less than 97% of maximum density as determined according to AASHTO T 99, Method D, with no individual test being less than 95% of maximum density.

If the specified density is not obtained for either type of base, rework or replace the material to comply with the density requirement.

3. Exclusions. Unless otherwise specified, the density requirements specified in **303.10.C.2** will not apply to:

a. Type A or Type B base construction on projects that do not include the construction of a surface upon the base, or to

b. Projects having a specified total base thickness of less than 4 inches.

When the specified density requirements do not apply, the Engineer will consider the desired degree of compaction to have been reached when the surface is tightly bound and shows no undue rutting or displacement under operation of the roller or other equipment. Obtain the Engineer's approval of the compaction of each layer before placing material for the next successive layer. Keep placing and compacting areas separate.

303.11 Maintenance

Maintain the completed base in a smooth and uniform condition until it is covered by the following stage of construction or the Project has been completed and accepted. Comply with the requirements of **104.05** regarding maintenance and protection.

303.12 Thickness Requirements

The thickness of the completed base shall be in reasonably close conformity to the thickness shown on the Plans. The thickness will be measured at such frequency as established by the Department using test holes or other approved methods.

303.13 Surface Requirements

The surface of the finished base shall be in reasonably close conformity to the lines, grades, and cross-sections shown on the Plans or established by the Engineer and shall have a satisfactorily smooth riding quality.

COMPENSATION

303.14 Method of Measurement

A. Mineral Aggregate for Mineral Aggregate Base, Type A or Type B

The Department will measure Mineral Aggregate for Mineral Aggregate Base, Type A or Type B, by the ton, in accordance with **109**.

B. Water

The Department will deduct the weight of total moisture, as determined by dry weights, of the base material at the time of weighing in excess of 3% of optimum moisture content.

The Department will not measure or pay for water when mixing is performed in a stationary plant,

When road mixing is performed, the Department will measure water added to the material at the direction of the Engineer by the M.G. (1,000 gallons) using calibrated tanks or distributors, or accurate water meters.

C. Sodium Chloride

The Department will measure sodium chloride by the ton in accordance with **109**.

D. Calcium Chloride

The Department will measure calcium chloride by the ton. The Department will weigh calcium chloride received in liquid form as specified in **109**, and will convert the weight of liquid calcium chloride to tons as follows:

1. 32% Solution

$$\text{Tons Calcium Chloride} = \frac{(\text{Total tons of 32\% solution}) \ \text{x } 0.32}{0.94}$$

2. 38 % Solution

$$\text{Tons Calcium Chloride} = \frac{(\text{Total tons of 38\% solution}) \ \text{x } 0.38}{0.94}$$

The Department will consider calcium chloride liquor used in a solution of 32% or more, but less than 38%, as a 32% solution. The Department will consider a solution of 38% or greater as a 38% solution.

303.15 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Mineral Aggregate, Type ____ Base	Ton
Calcium Chloride	Ton
Sodium Chloride	Ton
Water	MG

The Department will pay for the work required to prepare the subgrade in accordance with **303.07** as provided for in the applicable Section or Subsection under which the work is performed.

SECTION 304 – SOIL-CEMENT BASE

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DESCRIPTION

304.01 Description

This work consists of mixing in-place or select soil with Portland cement, and moistening and compacting the soil-cement mixture in one or more courses.

MATERIALS

304.02 Materials

Provide materials as specified in:

Portland Cement, Type I..... **901.01**
Portland-Pozzolan Cement, Type IP..... **901.01**
Bituminous Curing Seal, Emulsified Asphalt,
Types allowed for Tack Coat in **403**..... **904.03**
Select Material for Soil-Cement Base..... **921.05**

Provide water as specified in **302.03.B**.

Provide emulsified asphalt, of a type allowed for Tack Coat in **403**, meeting the test requirements specified in Table **904.03-1**.

The Contractor may select the kind of bituminous material to use for curing.

Submit a sample of the cement and the select material to be used to the Materials and Tests Laboratory for approval at least 15 days before use.

EQUIPMENT

304.03 Equipment

Provide a mechanical cement spreader that will distribute the cement uniformly at the required rate without excessive loss.

Provide mechanical mixers meeting **309.03.B**; or a stationary mixing plant meeting **309.03.A**.

CONSTRUCTION REQUIREMENTS

304.04 Limitations

Only process the amount of soil-cement that will be covered with the succeeding stage of base or pavement construction during the same construction season. Only apply cement to subgrade or select material that is unfrozen and when the air temperature in the shade is at least 40 °F and rising.

Limit application of cement to an area that will allow for continuous operations and for the completion of all but the final surface finish within three hours from the time the cement is applied. Do not leave any uncompacted soil-cement mixture undisturbed for more than 30 minutes.

If the uncompacted soil-cement mixture is wetted by rain so that the average moisture content exceeds the specified tolerance, reconstruct the entire section as specified in **304.13**.

304.05 Preparing the Existing Subgrade

If in-place soil is to be used, grade and shape the area to be treated as required to construct the soil-cement base in reasonably close conformity with the lines, grades, thickness, and cross-sections shown on the Plans. Place any additional soil needed as directed and blend with the in-place material. Remove unsuitable soil or material and replace with acceptable soil. When removing and replacing unsuitable soil, and placing additional soil, comply with the pertinent provisions of **203**.

Where only select material is to be used, prepare the subgrade as specified in **205**, **207**, or **302**, whichever is applicable.

Slightly dampen the subgrade just before spreading the select material or soil-cement mixture upon it.

304.06 Pulverizing

If required, before applying cement, scarify the soil to be treated and pulverize for sufficient depth and width to achieve, after treatment and compaction, the cross-section shown on the Plans. Pulverize the soil-cement mixture so that, at the completion of mixing, 100% will pass a 1-inch sieve, and a minimum of 80% by dry weight will pass a No. 4 sieve, exclusive of gravel or stone retained on these sieves. Remove material retained on a 3-inch sieve and other unsuitable material.

304.07 Cement Application, Mixing, and Spreading

Use an approved mechanical spreader to spread select material on the subgrade before mixing to the required thickness, width, and cross-section. The Engineer will establish the percentage of cement to be used based on tests of the in-place soil or select material.

Apply the specified quantity of Portland cement uniformly over the spread select material or in-place soil. Do not apply cement if the moisture content of the soil exceeds by more than 3% the optimum moisture content specified by the Engineer for the soil-cement mixture. Before starting mixing, replace spread cement that has been lost due to the Contractor's negligence at no additional cost to the Department.

Use a mechanical mixer to perform road mixing. At least one pass of the mixer may be required before adding water. When required, add water uniformly by distributors or other approved methods to bring the mixture to the required moisture content. Continue mixing until the pulverization requirements of **304.06** are met and a homogeneous mixture of soil, cement, and water is obtained.

If using stationary plants or mixers, ensure they are equipped with feeding and metering devices that will introduce the cement, soil, and water into the mixer in the quantities specified. All material fed into the plant shall travel the full length of the pugmill. Continue mixing until a uniform and intimate mixture of cement, soil, and water has been obtained. Transport the mixture from the plant to the road in numbered trucks equipped with tight metal rear-end dump beds. Provide a sufficient number of trucks to ensure satisfactory progress of construction operations.

Spread the material using approved mechanical spreaders within one hour after being discharged from the mixer and in ample time to secure compaction during daylight hours. If the moisture content of the uncompacted mixture exceeds the specified tolerance, reconstruct the material as specified in **304.13**. When mixing, handling, and placing the base material, take care to prevent segregation.

When using select material, place shoulder material for a width of at least 3 feet before spreading the base material in order to confine the base material and allow satisfactory compaction along the edges of the base.

304.08 Compaction

At the start of compaction, the percentage of moisture in the mixture and in the pulverized soil lumps, based on oven-dry weights, shall not vary more than 2% above or below the specified optimum moisture content, and shall be less than the quantity that will cause the soil-cement mixture to become unstable during compaction and finishing. The Contractor may use any type of compaction equipment that will produce the required results. Extend rolling over the edges of the base material into the shoulders.

After initial compaction and during final rolling, reshape the surface of the base course and lightly scarify to loosen any imprints left by the compacting or reshaping equipment.

The Department will divide the soil-cement base into lots of approximately 10,000 square yards for density testing purposes, and will perform five

density tests on each lot. The average dry density of each lot shall be not less than 95% of maximum density as determined according to AASHTO T 134, and no individual test shall be less than 92% of the maximum density. Rework material not meeting the required density at no additional cost to the Department, unless conditions exist as described in **304.13**. At the beginning of a project or at any time it is deemed advisable, smaller lots may be considered to evaluate rolling procedures or for other reasons as approved or directed by the Engineer.

Complete compaction and final shaping operations within three hours from the time the cement is mixed with the soil or select material.

304.09 Finishing

After compaction, shape the surface of the soil-cement to the required lines, grades, and cross-sections. Sprinkle the surface until it is damp, but not wet, and clip with a motor grader as directed by the Engineer. Dispose of the material removed by clipping. Following clipping, seal the surface with a roller.

304.10 Construction Joints

At the beginning of each day's construction, form a straight transverse construction joint by cutting back into the previously completed work to form a true vertical face free of loose or shattered material.

304.11 Thickness and Surface Tolerances

The finished base shall meet the surface requirements specified in **407.18**, and when tested as specified in that Subsection, the deviation of the surface from the testing edge of the straight edge shall not exceed 1/2 inch.

The Department will determine the thickness of the base by measuring test holes dug at random locations at intervals not to exceed 500 feet. The measured thickness shall not deviate from that shown on the Plans by more than plus 1-1/2 inches or minus 1 inch. Reconstruct or replace work found not to be within this tolerance as specified in **304.13**.

304.12 Curing

After the soil-cement has been finished, protect it against drying for 7 days by applying one of the bituminous materials specified in **304.02**. Apply the curing material at the rate shown on the Plans as soon as possible after

completing the base construction, but in no case later than 24 hours after completing finishing operations. Maintain the finished soil-cement in a continuously moist condition until the curing material is placed.

If construction equipment or other traffic must use the bituminous-covered surface before the bituminous material has dried sufficiently to prevent pickup, first apply sufficient granular cover, consisting of clean sand passing a 3/8-inch sieve or other approved material.

During the 7-day protection period, maintain the curing material to ensure that all of the soil-cement remains effectively covered.

Protect finished portions of soil-cement that are traveled on by equipment used in constructing an adjoining section so as to prevent equipment from marring or damaging completed work.

Sufficiently protect soil-cement from freezing for 7 days after its construction.

304.13 Reconstruction and Replacement

If reconstruction becomes necessary, repeat all construction procedures and adhere to the time limitations specified in this Section **304**; however, the Engineer will determine the amount of cement to be used in the reconstructed soil-cement base.

Replace faulty work for the full depth of treatment. Correct low areas by replacing the material for the full depth of treatment rather than by adding a thin layer of soil-cement to the completed work.

304.14 Traffic

The Contractor may open completed portions of soil-cement to local traffic after the 7-day curing period, provided the soil-cement has hardened sufficiently to prevent marring or distorting of the surface by equipment or traffic. However, provide ingress and egress for property owners and public crossroads as necessary before the 7-day curing period.

304.15 Maintenance

Maintain the soil-cement in good condition until all work has been completed and accepted. Immediately repair defects that may occur at no additional cost to the Department.

COMPENSATION

304.16 Method of Measurement

The Department will measure:

1. Processing by the square yards of completed base, as determined using the actual length measured along the center-line of the roadbed and the width shown on the Plans or designated by the Engineer.

2. Material moved to prepare the existing subgrade, in accordance with **304.05**, as provided for under the appropriate provisions of **203** or **207**.

3. Portland Cement incorporated in the work by the ton in accordance with **109**.

4. Bituminous Material used for curing seal by the ton in accordance with **109**.

5. Water used in mixing and finishing operations by the M.G. (1,000 gallons) using calibrated tanks or distributors, or accurate meters.

6. Select Material for Soil-Cement Base, added to that already on the road, by the cross-section method in approved borrow pits, in accordance with **203.09**.

The Department will not measure or pay for water added to emulsified asphalt used for curing.

304.17 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Processing (Soil-Cement Base)	Square Yard
Portland Cement (Soil-Cement Base)	Ton
Bituminous Material	Ton
Water	MG
Select Material (Soil-Cement Base)	Cubic Yard

The Department will not pay for reconstructive work, including additional cement and processing, required due to the Contractor's negligence.

The Department will not pay for the furnishing and spreading of granular cover used to protect, in accordance with **304.12**, bituminous surfaces opened to equipment and other traffic before the surface has sufficiently dried.

SECTION 306 – PORTLAND CEMENT CONCRETE BASE

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DESCRIPTION

306.01 Description

This work consists of constructing a single course of Portland Cement Concrete Base, with or without reinforcement, as specified, on a prepared surface.

MATERIALS

306.02 Materials

Provide materials as specified in:

Portland Cement, Type I	**901.01**
Fine Aggregate	**903.01**
Coarse Aggregate	**903.03**
Concrete Reinforcement	**907**
Curing Materials	**913**
Water	**921.01**
Air Entraining Admixtures	**921.06.A.2**
Chemical Additives	**921.06**

EQUIPMENT

306.03 Equipment

Provide equipment as specified in **501.04**.

CONSTRUCTION REQUIREMENTS

306.04 Proportioning

Proportion materials for concrete base as specified in **501.03**.

306.05 General

Prepare the subgrade as specified in **205**, **207**, or **302**, whichever is applicable. Perform sub-base or subgrade treatment, when specified, according to the applicable Sections of Part 3 of these Specifications.

To construct cement concrete base, apply the applicable methods and procedures specified in **501.07**, **501.09** through **501.15**, **501.16.A** through **501.16.F**, and **501.17** through **501.24**.

306.06 Surface Finish and Tolerances

Slightly roughen the surface of the concrete base by brooming. Meet the surface tolerances specified in **501.17**.

306.07 Integral Curb

Construct edging (integral curb), when shown on the Plans or required by the Engineer, of the same concrete mixture as is used in the base. Construct edging to the width and height shown on the typical cross-section by securely fastening auxiliary forms to the regular side forms of the base. Except as otherwise directed by the Engineer, construct edging immediately after the final floating of the base and before the concrete in the base upon which the edging is to be constructed has taken its initial set. Roughen the surface of the base before placing edging material upon it. At the end of the day's work, the Contractor may temporarily omit the curb from a section of the base sufficient in length to provide for backing-up of the paving train the following day, provided the base upon which the curb is to be placed is roughened sufficiently to bond the curb to the base. Remove all laitance from this section for the full width of the curbs by wire brushes or other

satisfactory means. Ensure that the concrete placed in the edging is well tamped and spaded to avoid honeycomb. The top of the edging shall be smooth and uniform and given a wood float finish. Shape the inside and outside edges with edging tools to the radii shown on the Plans. For final finishing of the edging, wipe the surface with a soft brush having a width not less than the width of the edging.

306.08 Tolerance in Base Thickness

For base thickness, meet the tolerance specified for pavement thickness in **501.24**.

COMPENSATION

306.09 Method of Measurement

The Department will measure Portland Cement Concrete Base (Plain) and Portland Cement Concrete Base (Reinforced) of the various thicknesses specified by the square yard in accordance with **109**.

If during construction the Engineer orders the cement increased or decreased from that approved for the job mix by more than 8 pounds per cubic yard, the Department will calculate the quantity of increased or decreased cement in accordance with **501.25**. These calculations will provide the basis for payment to the Contractor for additional cement, or for reimbursement to the Department for reduction in cement, as applicable.

306.10 Basis of Payment

A. General

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Portland Cement Concrete Base (Plain) ___"	Square Yard
Portland Cement Concrete Base (Reinforced) ___"	Square Yard

Such payment is full compensation for furnishing and placing all materials, including edging when specified, and for providing reinforcing, dowels, and joint materials.

The Department will pay for additional cement required if the cement is increased by more than 8 pounds per cubic yard at the purchase price, F.O.B. the unloading point, as verified by invoices, and will provide no additional compensation for further handling.

If the cement is decreased by more than 8 pounds per cubic yard, the Department will be reimbursed from any monies due the Contractor an amount equal to the purchase price of the cement, F.O.B. the unloading point, and no other charges will be included. The Department will not pay for any changes in the proportions of the aggregates.

The Department will not make additional payment for concrete slab placed in excess of Plan thickness.

The Department will not pay for any concrete base removed by order of the Engineer for deficiency in thickness or for otherwise not meeting Specification requirements.

For any base found to be deficient in thickness by more than 1/4 inch, but not more than 1 inch, the Department will only pay the reduced price specified in **306.10.B**.

The Department will pay for work required to prepare the subgrade or sub-base in accordance with **306.05** as provided for in the applicable Section or Subsection under which the work is performed.

B. Thickness Adjustments

Where the average thickness of base is deficient in thickness by more than 1/4 inch, but not more than 1 inch, the Department will pay an adjusted price as specified in the Table 306.10-1.

Table 306.10-1: Concrete Base Deficiency

Deficiency in Thickness as Determined by Cores (inches)	Proportion of Concrete Price Allowed
¼	100%
> ¼ through ½	75%
> ½ through ¾	60%
> ¾ through 1	50%

Where the thickness of base is deficient by more than 1 inch and, in the Engineer's judgment, the area of such deficiency should not be removed and replaced, the Department will not make payment for the area retained.

SECTION 307 – BITUMINOUS PLANT MIX BASE (HOT MIX)

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DESCRIPTION

307.01 Description

This work consists of constructing one or more base course layers of aggregate and asphalt, prepared in a hot bituminous mixing plant and spread and compacted on a prepared subgrade, granular sub-base, or base.

MATERIALS

307.02 Materials

Provide materials as specified in:

Aggregate for Mixture,
Grading A, ACRL, AS, B, BM, BM2, C, CS, or CW **903.06**
Asphalt Cement, Grade PG 64-22, 70-22, 76-22, 82-22..... **904.01**
Chemical Additive **921.06.B**

The specific grading of aggregate to be used will be specified in the Contract or shown on the Plans. The Engineer will accept mineral aggregate, bituminous material, and the plant mix in accordance with **407.02**.

307.03 Composition of Mixtures

A. General

The bituminous base and/or leveling course shall be composed of aggregate and bituminous materials. The hot plant mixes shall comply with the applicable requirements of **407.03**.

Combine the specified mineral aggregate and asphalt cement in proportions that will meet the design composition limits specified in Table 307.03-1.

Table 307.03-1: Mixture Composition

Mixtures	Proportions of Total Mixture, Percent by Weight	
	Combined Mineral Aggregate, %	**Asphalt Cement, % [(1)]**
Grading AS and ACRL	96.3 - 97.7	2.3 - 3.7
Grading A	95.8 - 96.7	3.3 - 4.2
Grading B, BM and BM2	93.8 - 95.8	4.2 - 6.2
Grading C and CW	93.8 - 95.8	4.2 - 6.2
Grading CS	92.3 - 94.7	5.3 - 7.7

(1) If the effective combined specific gravity of the aggregate exceeds 2.80, the Engineer may adjust the proportions specified.

In addition, combine the materials with the required amount of bitumen to meet the design properties specified in Table 307.03-2, except that on low volume roads (ADT 1,000 or below), the minimum stability shall be 1,500 pound-feet and the VMA and dust-asphalt ratio will be waived for 307-B, 307-BM, 307-BM2 and 307-C mixes.

Table 307.03-2: Mixture Design Properties

Mix [1]	Stability (minimum) lbf [2]	Design Void Content % [2]	Production Void Content, % [2]	VMA (minimum) % [2]	Dust-Asphalt Ratio [3]
307-B	2,000	4.0±0.2	3-5.5	11.5	0.6-1.5
307-BM	2,000	4.0±0.2	3-5.5	13.5	0.6-1.5
307-BM2	2,000	4.0±0.2	3-5.5	13.5	0.6-1.5
307-C	2,000	4.0±0.2	3-5.5	13.0	0.6-1.5
307-CS	2,000	3.0±0.5	1-5	---	---
307-CW	1,500	4.0±0.2	3-5	13.0	0.6-1.5

[1] To identify critical mixes and make appropriate adjustments, the mix design shall meet these design properties for the bitumen content range of Optimum Asphalt Cement ±0.25%.

[2] Tested according to AASHTO T 245 with 75 blows with the hammer on each end of the test specimen, using a Marshall Mechanical Compactor.

[3] The dust-asphalt ratio is the percent of the total aggregate sample that passes the No. 200 sieve, as determined by AASHTO T 11, divided by the percent asphalt in the total mix.

If the materials proposed for use do not meet the design criteria specified in Table 307.03-2, find other suitable sources of materials. If the material at the asphalt plant will not combine within the tolerances of the Job Mix Formula (JMF), provide a new design.

B. Recycled Asphalt Pavement and Recycled Asphalt Shingles

1. Recycled Asphalt Pavement (RAP). The Contractor may use asphaltic concrete removed from a Department project or other State Highway Agency project by an approved method and stored in a Department approved stockpile. RAP combined with the appropriate aggregate, asphalt cement, and anti-strip additive when required shall produce a mixture that meets **903.06** and this Section **307**. The Contractor may incorporate RAP in the mixes specified in Table 307.03-3.

Table 307.03-3: Mixtures Using RAP

Mix Type	% RAP (Non-processed)[1]	Maximum % RAP (Processed)[2]	Maximum % RAP Processed & Fractionated [3]	Maximum Particle Size (inches)
307-ACRL	0	00	-	-
307-AS	0	00	-	-
307-A	15	20	35	1-1/2
307-B	15	30	35	1-1/2
307-BM	15	30	35	3/4
307-BM2	15	30	35	3/4
307-C	15	30	35	3/8
307-CW	15	30	35	1/2
307-CS	0	15	25	5/16

(1) "Non-processed" refers to RAP that has not been crushed and screened or otherwise sized prior to its use.

(2) "Processed" refers to RAP that has been crushed and screened or otherwise sized such that the maximum recycled material particle size is less than that listed in Table 307.03-3 prior to entering the dryer drum.

(3) "Fractionated" refers to RAP that has been processed over more than one screen, producing sources of various maximum particle sizes (e.g., 3/4 to 1/2 inch, 1/2 inch to #4, etc.). The Contractor may use the larger percentages of fractionated RAP specified only if individual fractions of two different maximum particle size are introduced into the plant as separate material sources for increased control.

All mixes shall contain at least 65% virgin asphalt.

The Contractor shall obtain a representative sample from the recycled material stockpile, and shall establish a gradation and asphalt cement content. The Contractor shall determine the gradation and asphalt content of the recycled material at the beginning of a project and every 2,000 tons thereafter. The stockpile asphalt cement content for all recycled material shall not

vary by more than 0.8%. The stockpile gradation tolerance for all recycled material on each sieve is specified in Table 307.03-4.

Table 307.03-4: Stockpile Gradation Tolerance

Sieve Size	Tolerance
3/8 inch and larger	± 10%
No. 4	± 8%
No. 8	± 6%
No. 30	± 5%
No. 200	± 4%

The Engineer will accept the mixture for aggregate gradation and asphalt content in accordance with **407.20.B**.

Provide a special mix design with asphalt content in the range of 5 to 7% where 307-C Mix is used as a surface on the shoulder.

Perform sampling and testing of the planings as well as new materials for bid purposes, and for the submission of the Job Mix Formula (JMF) as specified in **407.03**. Submit all additives to the Engineer for approval at the same time other materials are submitted for design verification.

After mixing, verify the moisture content of the total mix is no more than 0.1% as determined by oven drying. Provisions for lowering the temperature because of boiling or foaming shall not apply.

2. **Recycled Asphalt Shingles (RAS).** RAS may be included to a maximum of 5% of the total weight of mixture. The percentage of RAS used will be considered part of the maximum allowable RAP percentage. The ratio of added new asphalt binder to total asphalt binder shall be 65% or greater for all 307 mixes. Either the mix producer or the RAS supplier shall obtain a representative sample from the recycled material stockpile and establish a gradation and asphalt cement content as required. Determine shingle asphalt binder content according to AASHTO T 164 Method A, with a minimum sample size of 500 grams. Determine the gradation and asphalt content of the recycled material at the beginning of the

Project and every 2,000 tons of recycled material used thereafter. The stockpile asphalt cement content for all recycled material shall not vary by more than 0.8%. All RAS material shall be processed to a minimum 100% passing the 3/8 inch sieve and a minimum 90% passing the No. 4 sieve.

To conduct the gradation testing, air dry a 500 to 700-gram sample of processed shingle material, dry sieve over the 3/8-inch and No. 4 sieves, and weigh. For mix design purposes, the Contractor may use the aggregate gradation specified in Table 307.03-5 as a standard gradation instead of determining the shingle gradation according to AASHTO T 30.

Table 307.03-5: Standard Gradation (for Mix Design Purposes)

Sieve Size	Total Percent Passing
3/8 inch	100
No. 4	97
No. 8	95
No. 16	80
No. 30	60
No. 50	50
No. 100	40
No. 200	30

An aggregate bulk specific gravity (G_{sb}) of 2.650 may be used instead of determining the shingle aggregate G_{sb} according to AASHTO T 84. In addition, the effective binder available for mixing with additional aggregates shall be considered as 75% of the total binder content as determined by AASHTO T 164 and shall be the value listed as the RAS binder content on the JMF.

Scrap asphalt shingle shall not contain extraneous waste materials. Extraneous materials including, but not limited to, asbestos, metals, glass, rubber, nails, soil, brick, tars, paper, wood, and plastics, shall not exceed 0.5% by weight as determined on material retained on the No. 4 sieve. To conduct deleterious material testing, take a representative 500 to 700-gram sample of processed shingle material, place over the No. 4 sieve, and pick

and weigh all extraneous waste material retained on the No. 4 sieve. Base the percent of extraneous material on the total sample weight.

RAS shall contain less than the maximum percentage of asbestos fibers based on testing procedures established by the Department, or State or Federal environmental regulatory agencies. Analyze a minimum of one sample of processed asphalt roofing material for every 500 tons of material processed for the presence of asbestos.

Before a JMF for a particular design is approved, submit the following, along with the materials and information specified in **407.03**:

a. Certification by the processor of the shingle scrap describing the shingle scrap content and source.

b. A 1000-gram sample of the processed RAS material for inspection (new designs only).

Stockpile RAS separate from other salvage material. Do not blend RAS material in a stockpile with other salvage material. Do not blend Manufacture Waste Scrap Shingles (MWSS) and Tear-Off Scrap Shingles (TOSS). In addition, do not blend virgin sand material with the processed shingles, to minimize agglomeration of the shingle material.

All RAS supplied to a Department project shall come from a certified shingle processor/supplier approved by the Division of Materials and Tests.

C. Anti-Strip Additive

Check asphaltic concrete mixtures (Grading A, AS, ACRL, B, BM, BM2, C, CS, and CW) for stripping by the following methods:

1. The Ten Minute Boil test for dosage rate and the Root-Tunnecliff procedure (ASTM D4867) for moisture susceptibility.

   Do not use the Root-Tunnecliff procedure (ASTM D4867) with the following mixtures: Grading A, AS, ACRL, and B.

2. For mixtures not requiring design, the Ten Minute Boil test for dosage rate and moisture susceptibility.

If test results indicate moisture susceptibility, mix an approved anti-strip agent with the asphalt cement at the dosage recommended by the respective test and as specified in **921.06.B**.

EQUIPMENT

307.04 Equipment

Provide equipment as specified in **407.04** through **407.08**.

If using recycled mix, modify the asphalt plant as approved by the Engineer to accommodate the addition of asphalt planings. If using a batch plant to produce recycled mix, heat the aggregate to a temperature that will transfer sufficient heat to the cold planings to produce a mix of uniform temperature within the specified range.

CONSTRUCTION REQUIREMENTS

307.05 General

Conform to the construction requirements specified in **407.09**, and **407.11** through **407.17**.

307.06 Preparing the Subgrade, Sub-base, or Surface

The Plans will indicate whether the plant-mixed base is to be constructed on a treated or untreated subgrade or sub-base, on a granular base, or on an existing surface. Ensure that the surface upon which the plant mix base is to be constructed meets **205**, **207**, **302**, **303**, **304**, or **309**, whichever is applicable. If shown on the Plans, condition the surface as specified in **407.10**. Condition existing mineral aggregate base as specified in **310**. Construct prime coat or tack coat, when shown on the Plans, as specified in **402** or **403**, respectively.

Only place bituminous plant-mix base mixture on a surface that is dry and free of loose particles and other undesirable materials.

307.07 Thickness and Surface Requirement

Control thickness during the spreading operation by frequently measuring the freshly spread mixture to establish a relationship between the uncompacted mixture and the completed course. Thickness or spread rate in pounds per square yards shall be within reasonably close conformity with that shown on the Plans. Each course shall have a thickness after compaction of not more than 4 inches, unless otherwise approved by the Engineer.

The surface of the base shall meet the requirements specified in **407.18**, and when tested in accordance with **407.18**, the deviation of the surfaces from the testing edge of the straightedge shall not exceed the amounts specified in Table 307.07-1.

Table 307.07-1: Maximum Surface Deviation

Mixture	Maximum Deviation (inches)
Grading A, ACRL, and AS	1/2
Grading B, BM, BM2, C, CS, and CW	3/8

COMPENSATION

307.08 Method of Measurement

The Department will measure Mineral Aggregate, including Mineral Filler when required, and Asphalt Cement for Bituminous Plant Mix Base and other related items in accordance with **407.19**.

307.09 Basis of Payment

The Department will pay for accepted quantities at the contract prices in accordance with **407.20**.

For bidding purposes, use the asphalt cement content specified in Table 307.09-1 for the designated mix.

Table 307.09-1: Asphalt Cement Content

Mix Type	Asphalt Content
307 A	4.0%
307 AS	3.5%
307 ACRL	3.5%
307 B	4.3%
307 BM	5.0%
307 BM2	5.0%
307 C	5.0%
307 CW	6.0%
307 CS	6.5%

If the Engineer sets an asphalt content other than that specified in Table 307.09-1, the Department will calculate a price adjustment, based on the asphalt content set by the Engineer and the Monthly Bituminous Index for the specific grade asphalt on the mix design, in accordance with **407.20**.

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DESCRIPTION

309.01 Description

This work consists of constructing a base of mineral aggregate and Portland cement on a prepared surface.

MATERIALS

309.02 Materials

Provide materials as specified in:

Water	**302.03.B**
Portland Cement, Type I	**901.01**
Portland-Pozzolan Cement, Type IP	**901.01**
Crushed Stone or Slag, Grading D	**903.05**

Aggregate, Crushed or Uncrushed Gravel or Chert **903.15**
Bituminous Material for Curing, Emulsified Asphalt,
Types allowed for Tack Coat in **403**..... **904.03**

Provide emulsified asphalt, of a type allowed for Tack Coat in **403**, meeting the test requirements specified in Table **904.03-1**.

Submit a sample of the cement and aggregate to be used to the Materials and Tests Laboratory for approval at least 15 days before use.

EQUIPMENT

309.03 Equipment

Provide a stationary mixing plant or mechanical road mixer(s).

A. Stationary Mixing Plant

Provide an approved twin-shaft pugmill as specified in **303.06.A**.

The cement feeder shall include a surge tank between the cement supply and the pugmill. The feeder system shall be so designed that the aggregate feeder will not operate unless the cement feeder operates. During production of aggregate cement base, do not use the plant for other operations. The plant shall be capable of weighing each component and adjusting for moisture in the aggregates. Plants shall be calibrated annually and in the presence of the Engineer if requested.

B. Mechanical Mixer (for Road Mixing)

Provide pugmill or rotary type mechanical mixers capable of producing a uniform blend of all materials to the full depth of the course being placed. At least one mixer shall be capable of adding a regulated amount of water under pressure and uniformly mixing it with the aggregate and cement. The mixers may be either self-propelled or trailer type.

CONSTRUCTION REQUIREMENTS

309.04 Limitations

Only process the amount of aggregate-cement base that will be covered with the succeeding stage of base or pavement construction during the same construction season. Do not process aggregate-cement base unless the ambient air temperature is at least 40 °F in the shade and rising. Only add cement to aggregate that is free of frost, whether the aggregate is stockpiled for plant mixing or spread for roadway mixing.

For roadway mixing, limit application of cement to an area that will allow for continuous operations and for the completion of all but the final surface finish within 3 hours from the time cement is applied.

When using a stationary mixing plant, spread the material, using approved mechanical spreaders, within 1 hour after being discharged from the mixer. Complete all operations except final surface finishing within 3 hours after the material is discharged from the mixer.

Continue processing the uncompacted aggregate-cement mixture with no delay of more than 30 minutes. If the uncompacted aggregate-cement mixture is wetted by rain so that the average moisture content exceeds the specified tolerance, reconstruct the section as specified in **304.13**.

309.05 Preparing the Existing Subgrade

Before beginning other construction operations, prepare the subgrade as specified in **205**, **207**, or **302**, whichever is applicable.

309.06 Cement Application, Mixing, and Spreading

The quantity of cement to be added to the aggregate shall range between 3% and 5%, by weight, of the dry material. The Engineer will establish the exact percentage of cement within the above range based on tests of the aggregate selected for use on the project.

A. Roadway Mixing

Spread the aggregate on the subgrade to the required thickness, width, and cross-section using an approved mechanical spreader. Uniformly apply the specified quantity of Portland cement over the spread

aggregate using an approved mechanical cement spreader. Do not apply cement if the moisture content of the aggregate exceeds by more than 4% the optimum moisture content specified by the Engineer for the aggregate-cement mixture. Replace spread cement that has been lost due to the Contractor's negligence at no additional cost to the Department.

Perform road mixing using mechanical mixer(s). At least one pass of the mixer may be required before adding water. When required, add water through the mixer or by other approved methods to bring the mixture to the required moisture content. Continue mixing until a uniform mixture is obtained.

B. Stationary Mixing Plant

If using a stationary plant, continue mixing until a uniform and intimate mixture of cement, aggregate, and water has been obtained. All material fed into the plant shall travel the full length of the pugmill. Periodically check the quantity of cement expended by emptying the cement storage bin. Transport the mixture from the plant to the road in numbered trucks equipped with tight, metal, rear-end dump beds. Provide a sufficient number of trucks to ensure satisfactory progress of the construction operations. Use an approved mechanical spreader to spread the material. In mixing, handling, and placing the base material, take care to prevent segregation.

Place shoulder material for a width of at least 3 feet before spreading the base material in order to confine the base material and allow satisfactory compaction along the edges of the base.

309.07 Compaction

The Contractor may use any type of compacting equipment that will produce the required result. At the start of compaction, the percentage of moisture in the mixture based on oven dry weight shall not vary more than 3% above or 1% below the specified optimum moisture. Extend rolling over the edges of the base material onto the shoulders.

The Department will divide the completed base into lots of approximately 10,000 square yards for density testing purposes, and will perform five density tests on each lot. The average dry density of each lot shall be not less than 95% of maximum density as determined according to AASHTO T 134, and no individual test shall be less than 92% of maximum density.

Rework or replace material not meeting the specified density. At the beginning of a project or at any time it is deemed advisable, smaller lots may be considered to evaluate rolling procedures or for other reasons as approved or directed by the Engineer.

309.08 Finishing

Perform finishing operations in the same manner as specified for soil-cement base construction in **304.09**.

309.09 Construction Joints

At the beginning of each day's construction, form a straight transverse construction joint by cutting back into the completed work to form a true vertical face.

Build aggregate-cement base for large, wide areas in a series of parallel lanes of convenient length and width meeting the approval of the Engineer. Form straight longitudinal joints at the edge of each day's construction by cutting back into the completed work to form a true vertical face free of loose or shattered material.

309.10 Thickness and Surface Tolerances

The thickness of the base will be determined from the measurement of test holes dug at random locations or other approved methods. The measured thickness shall not deviate from that shown on the Plans or directed by the Engineer by more than plus 1-1/2 inches or minus 1 inch. Reconstruct or replace work found not to be within the above tolerance as specified in **304.13**.

The surface of the completed base shall be in reasonably close conformity to the lines, grades, and cross-section shown on the Plans or established by the Engineer and shall have a satisfactorily smooth riding quality.

309.11 Curing

Perform curing of the finished base in the same manner as specified for soil-cement base construction in **304.12**.

309.12 Traffic and Maintenance

The Contractor may open portions of completed base to traffic as specified in **304.14**.

Maintain the completed base as specified in **304.15**.

COMPENSATION

309.13 Method of Measurement

The Department will measure:

1. Mineral Aggregate for Aggregate-Cement Base Course by the ton in accordance with **109**.

2. Earth moved to prepare the existing subgrade, in accordance with **309.05**, as provided for under the appropriate provisions of **203** and **207**.

3. Portland Cement incorporated in the work by the ton in accordance with **109**.

4. Bituminous Material used for curing seal by the ton in accordance with **109**.

5. Water used in mixing and finishing operations by the M.G. (1,000 gallons) using calibrated tanks or distributors, or accurate meters.

The Department will deduct the weight of total moisture, as determined by dry weights, of the base material at the time of weighing in excess of 3% of optimum moisture content.

The Department will not measure or pay for water added to emulsified asphalt used for curing.

309.14 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Mineral Aggregate	Ton
Portland Cement	Ton
Bituminous Material	Ton
Water	MG

When mixing is performed in a stationary plant, the Department will not pay for water. When road mixing is performed, the Department will pay for water added to the material during mixing at the direction of the Engineer.

SECTION 310 – CONDITIONING MINERAL AGGREGATE BASE

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DESCRIPTION

310.01 Description

This work consists of reshaping and compacting an existing mineral aggregate base or surface.

MATERIALS

310.02 Materials

Provide materials as specified in:

Aggregate for Conditioning Base	**903.05**
Calcium Chloride, Type 1, Type 2 or Calcium Chloride Liquor	**921.02**
Sodium Chloride	**921.03**

EQUIPMENT

310.03 Equipment

Provide motor graders and water distributors in the number necessary for satisfactory prosecution and completion of the work, as well as one or more

rollers of a type and sufficient weight to obtain the required density and to seal the surface of the base course.

CONSTRUCTION REQUIREMENTS

310.04 Conditioning

Condition the existing base by applying water, blading, and compacting as directed by the Engineer. Scarify sections of existing base that are pot-holed to the full depth of the pot holes. Scarify and shape warped and distorted sections as directed by the Engineer. Moisten the material as necessary, and mix, shape, and roll until the base is uniformly and thoroughly compacted. Continue applying water, blading, and rolling until a smooth, dense, well-bonded surface is obtained that meets the Engineer's approval.

The Department will divide the completed base into lots of approximately 10,000 square yards for density testing purposes, and will perform five density tests in each lot. The average dry density shall be not less than 100% of maximum density as determined according to AASHTO T 99 Method D, and no individual test shall be less than 97% of maximum density. Smaller lots may be considered when approved or directed by the Engineer.

Distribute calcium chloride or sodium chloride, when specified, at the approximate rate of 1 pound per square yard and incorporate it in the base material during blading and rolling operations as directed by the Engineer.

If additional material is to be added to the existing base, lightly scarify the existing base, add the material, and condition the base as specified above.

310.05 Surface Requirements

The surface of the conditioned base shall be in reasonably close conformity with the lines, grades, and cross-sections shown on the Plans or as directed by the Engineer and shall provide a satisfactory riding surface.

COMPENSATION

310.06 Method of Measurement

The Department will measure:

1. Conditioning Mineral Aggregate Base by the linear mile, based on a horizontal measurement made along the median centerline of the Project for divided sections and along the centerline of the pavement for two-lane sections, excluding bridges.

2. Calcium Chloride by the ton in accordance with **303.14.D**.

3. Sodium Chloride by the ton in accordance with **109**.

4. Water by M.G. (1,000 gallons) using calibrated tanks or distributors, or accurate water meters.

If the Contract requires the construction of a mineral aggregate base and a surface course, the Department will not directly measure or pay for conditioning of the base but will consider this work to be incidental to the unit price bid for the base material.

If the Contract requires the addition of base material to sections or the entire length of a previously constructed base, the Department will not directly measure or pay for conditioning of the base on the sections where base material is added. Sections where base material is not added will be measured for payment by the linear mile.

If the Contract requires a surface to be constructed on a previously constructed base and no additional material is added to the base, the Department will measure and pay for conditioning of the base by the linear mile.

310.07 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Conditioning Mineral Aggregate Base	Linear Mile
Calcium Chloride	Ton
Sodium Chloride	Ton
Water	MG

Payment for Conditioning Mineral Aggregate Base is full compensation for conditioning all base on interchanges, approaches, service roads, ramps, frontage roads, roadside rest areas, and all other base within the limits of the

Project that requires conditioning to receive a succeeding stage of construction under the Contract.

SECTION 312 – AGGREGATE-LIME-FLY ASH STABILIZED BASE COURSE

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DESCRIPTION

312.01 Description

This work consists of constructing a base of mineral aggregate, hydrated lime, and fly ash.

MATERIALS

312.02 Materials

Provide materials as specified in:

Crushed Limestone Aggregate Type A, Grading C **903.05**

Bituminous Material for Curing Emulsified Asphalt,
Types allowed for Tack Coat in **403**..... **904.03**
Water **921.01**
Lime..... **904.04**

Provide emulsified asphalt, of a type allowed for Tack Coat in **403**, meeting the test requirements specified in Table **904.03-1**.

Fly Ash shall meet the requirements of ASTM C593 except that loss on ignition shall not exceed 10% when tested according to ASTM C311, Section 11 and 12, and the combined silicon dioxide ($Si0_2$), aluminum oxide (Al_20_3) and iron oxide (Fe_20_3) shall be more than 60% when tested according to ASTM C311, Section 13 and 14.

312.03 Proportioning

Proportion the lime, fly ash, and aggregate to meet the limits specified in Table 312.03-1.

Table 312.03-1: Proportioning of Lime, Fly Ash, and Aggregate Mix

Material	Range of Percent by Weight of Total Dry Mix
Lime	3.5
Fly Ash	11.0
Aggregate	85.5

The mixture shall be within plus or minus 2% of the optimum moisture of the mixture, as determined according to AASHTO T 99, Method C (with replacement).

Design the mixture so that when compacted into cylinders, cured for 28 days at 100 °F, and tested according to ASTM C593, the cylinders will have a minimum average compressive strength of 950 psi and no individual test is lower than 800 psi.

At least 45 days before producing the stabilized mixture, submit the following for the Engineer's approval:

1. Mix design,

2. Statement naming the source and percentage of each component, and
3. Report showing the results of the applicable tests meeting the above requirements.

For material testing and verification of the mix design, submit component materials in the quantities specified in Table 312.03-2.

Table 312.03-2: Material Quantities for Mix Verification Testing

Material	Quantity (pounds)
Hydrated Lime	25
Fly Ash	50
Aggregate	200

The Engineer may choose to verify the mix design on an annual basis provided the properties and proportions of the materials do not change appreciably. Adhere to the approved proportions of material during the progress of the work. Do not change the source or character of any material without the Engineer's approval, which will be based on verification of the new mix design.

EQUIPMENT

312.04 Equipment

A. Mixing Plant

Provide a stationary or portable batch or continuous mix type mixing plant that is equipped so as to allow the Engineer to verify the component percentages at any time.

1. Stationary or Portable Batch Type Plants. Equip mixing plants with batching devices and scales to proportion the individual components by weight. Ensure that such devices have the accuracy needed to maintain the material percentages, based on total dry weight, within the tolerances specified in Table 312.04-1.

Table 312.04-1: Tolerances for Mix Components (based on dry weight)

Material	Tolerance
Hydrated Lime	± 0.25%
Fly Ash	± 0.75%
Water	± 2.0%

Equip stationary or portable batch type plants with scales as specified in **501.04.A.3**. Use separate scales and hoppers for weighing the aggregate and the lime and the fly ash; however, the fly ash may be weighed cumulatively in the weigh hopper with the lime, provided the lime is added first.

2. Continuous Type Mixing Plants. Equip continuous type mixing plants with:

1. Metering devices and scales for proportioning the lime and fly ash by weight so as to meet the tolerances specified in Table 312.04-1;

2. An out-of-range alarm system that will sound an audible alarm when the lime or fly ash is not within the established tolerances;

3. A meter or other approved regulating device to control the flow of water into the plant in a manner that positively maintains a uniform moisture content in the mixture; and

4. A separate, quick, and automatically operating on-off device to shut the water off instantly when the mixer stops.

Maintain an approved method of checking and calibrating the weighing system in an easily accessible location on the plant.

B. Rollers

Provide either pneumatic tire or vibratory type rollers as specified in **407.07**.

C. Spreader

Provide either a self-propelled or tractor-drawn spreader that is capable of maintaining a uniform rate of travel while spreading and of laying a lift of uniform consistency and thickness with proper grade control.

D. Haul Trucks

Transport the mixture from the central plant in clean, tight trucks having a cover of canvas, or other suitable material, securely fastened on all sides of the truck bed, and of such size as to maintain the moisture content and prevent the loss of fines.

CONSTRUCTION REQUIREMENTS

312.05 Limitations

The Contractor may perform stabilization from March 1st through September 30th, and may continue this operation from October 1st through November 30th provided that Type I Portland cement is substituted for the lime on a pound for pound basis. Do not perform stabilization when the aggregate or the surface on which the base course is to be placed is wet or frozen, when it is raining, sleeting, or snowing, or when the temperature is 40 °F or less. Do not begin processing operations for this material unless the air temperature in the shade is at least 40 °F and rising. Cover the aggregate-lime-fly ash stabilized base course with the succeeding stage of base or pavement construction before December 15th.

312.06 Subgrade Preparation

Prepare the subgrade as specified in **205**, **207**, or **302**, whichever is applicable.

312.07 Mixing

Mix the aggregate with the proper amount of lime, fly ash, and water in an approved mixer. Continue mixing until a thorough and uniform mixture is obtained. Handle the aggregate in a manner that will prevent contamination and segregation. Ensure that the plant is capable of discharging the mixture without undue segregation.

312.08 Spreading

After mixing, transport the material to the site while it contains the proper moisture content, and spread the material to the required thickness and cross-section using an approved spreader. If the required compacted depth of the base exceeds 8 inches, construct the base in two or more approximately equal layers. The maximum compacted thickness of any one layer shall not exceed 8 inches.

312.09 Compacting

The Contractor may use any type of compacting equipment that will produce the required result. At the start of compaction, the percentage of moisture in the mixture based on oven dry weight shall not vary more than 3% above or 1% below the specified optimum moisture. Extend rolling over the edges of the base material onto the shoulders.

The Department will divide the completed base into lots of approximately 10,000 square yards for density testing purposes, and will perform five density tests on each lot. The average dry density of each lot shall be not less than 100% of the maximum density as determined according to AASHTO T 99, Method C (with replacement), and no individual test shall be less than 97% of the maximum density. If the specified density is not obtained, rework or replace the material to comply with the density requirement.

The Engineer may employ a control strip and random sampling to evaluate and adjust the Contractor's rolling procedure.

Provide a sufficient number of compaction and finishing units to ensure that the initial compaction of the processed section of the stabilized base course is completed within 4 hours from the time the water is added at the mixer. The final finishing and compaction shall be within 8 hours from the time of mixing. The Engineer may extend this time if the material has not reached an initial set. If, for any reason, construction operations are delayed or suspended and the Engineer requires the removal and disposal of loose or uncompacted material, the Contractor shall perform this work at no additional cost to the Department. No aggregate-lime-fly ash base course may be salvaged.

312.10 Finishing

Perform finishing operations as specified in **304.09**.

312.11 Construction Joints

Construct joints as specified in **309.09**.

312.12 Thickness and Surface Requirements

Meet the thickness and surface requirements specified in **309.10**.

312.13 Curing

After finishing the aggregate-lime-fly ash base, seal the surface with one of the bituminous materials specified in **312.02**, applied by a pressure distributor at the rate of 0.10 to 0.25 gallons per square yard or as directed by the Engineer. Heat or otherwise prepare the bituminous material to ensure uniform distribution. Apply the material no later than 24 hours after completing finishing operations unless the Engineer determines that application should be delayed. Keep the finished base continuously moist until the bituminous curing seal has been applied. Maintain the curing material during a 7-day protection period so that all of the aggregate-lime-fly ash base course will be covered effectively during this period. Until the mixture has cured for 7 days, only allow on the base the pneumatic-tired equipment required for applying the curing seal. However, provide ingress and egress for property owners before the 7-day curing period.

312.14 Traffic and Maintenance

Meet **309.12**.

COMPENSATION

312.15 Method of Measurement

The Department will measure bituminous material for curing seal and the mineral aggregate, lime, and fly ash mixture by the ton in accordance with **109**.

The Department will deduct the weight of total moisture in the aggregate, as determined by dry weights, of the base material at the time of weighing in excess of 3% of optimum moisture. The Department will not measure and pay for mixing water; however, it will measure and pay for water added on the road at the direction of the Engineer by the M.G. (1,000 gallons) in accordance with **109**.

312.16 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Mineral Aggregate	Ton
Lime	Ton
Fly Ash	Ton
Bituminous Material	Ton
Water	MG

SECTION 313 – TREATED PERMEABLE BASE

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DESCRIPTION

313.01 Description

This work consists of constructing treated permeable base, composed of either a mixture of aggregate, Portland cement, and water, or a mixture of aggregate with asphalt binder, on a prepared sub-base. The Contractor may use either cement treated or asphalt treated permeable base.

MATERIALS

313.02 Materials

Provide materials as specified in:

Portland Cement, Type I	**901.01**
Aggregate for Portland Cement Treated Mixture	**903.03**
Aggregate for Bituminous Treated Mixture	**903.06**
Asphalt Cement, Grade PG 64-22, 70-22, 76-22, 82-22	**904.01**
Liquid Membrane – Forming Compounds	**913.05**
Water	**921.01**

313.03 Composition of Mixtures

A. Portland Cement Treated Permeable Base

In accordance with **604**, submit a concrete mix design, meeting the requirements specified in Table 313.03-1, to the Engineer for approval.

Table 313.03-1: Mix Design Properties

Property	Value
Water-Cement Ratio	0.43 (approximately)
Portland Cement Content	$\geq$ 282 lbs/yd^3
Compressive Strength at 7 days (AASHTO T 22)	$\geq$ 500 psi

B. Bituminous Treated Permeable Base

Asphalt treated permeable base shall be Bituminous Plant Mix Base (Hot Mix) as specified in **307** and **407**. Use liquid asphalt at the rate of 3% by weight of the total mixture. Asphalt content shall be such that all aggregate is visibly coated. Submit a mix design to the Engineer for approval as specified in **407.03**.

EQUIPMENT

313.04 Equipment

To construct Portland cement treated base, provide equipment meeting **501.04.A** and **501.04.B**.

To construct bituminous treated base, provide equipment meeting **407.04** through **407.08**.

The spreading equipment shall meet either **501.04.D.11** or **407.06**.

CONSTRUCTION REQUIREMENTS

313.05 Construction Requirements

Construct cement treated permeable base and asphalt treated permeable base as specified in **309** and **307** respectively, unless otherwise specified below.

A. Cement Treated Permeable Base

1. **Consolidation and Finishing.** Immediately after placing the cement treated permeable base, compact the mixture using a steel wheel roller weighing not less than 6 tons. Continue rolling until maximum densification is achieved; immediately cease rolling if aggregate breakage occurs. Do not use vibratory rollers. Instead of using a steel wheel roller, the Contractor may place the cement treated permeable base with a high-density screed with dual tamping bars.

2. **Curing.** Immediately after spreading and compacting operations, cover the entire surface and exposed edges of the cement treated permeable base with transparent or white polyethylene sheeting as specified in **501.18**, or a white pigmented wax base curing compound meeting AASHTO M 148.

   Use polyethylene sheeting having a thickness of at least 4 mils, and hold the sheeting in place for a minimum of 7 days using a method approved by the Engineer. Before placing the sheeting, thoroughly wet the surface of the cement treated permeable base.

   Place wax-based curing compound at a rate of 0.04 to 0.05 gallons per square yard.

B. Asphalt or Cement Treated Permeable Base

From the time of placement until placement of the following pavement layer, protect the treated permeable base from severe weather conditions, particularly freezing rain, snow, and icing, and from contamination by dust, dirt, mud, or other fine grained material. Remove and replace, at no additional cost to the Department, all portion(s) of the treated permeable base that become contaminated to the extent that drainage is reduced or inhibited.

Do not allow traffic on the treated permeable base, with the exception of equipment required to place the following layer of pavement, provided that it enters and exits as near as possible to the paving operation. Repair damage to the treated permeable base caused by the Contractor's equipment at no additional cost to the Department.

313.06 Limitations

If using asphalt treated permeable base, adhere to the limitations specified in **407.09**. Do not place any treated permeable base that cannot be covered by the next course of pavement within the same construction season.

313.07 Surface Requirements

The Department will test the finished surface of the treated permeable base with a 12-foot straightedge in both transverse and longitudinal directions. The finished surface shall be uniform and shall not vary by more than 1/2 inch from the lower edge of the straightedge. If the tested surface varies by more than 1/2 inch, adjust the surface to a new grade, as established by the Engineer, as follows:

1. Fill the low areas with Portland cement concrete during the concrete paving operation, or

2. Apply emulsified asphalt, RS-2, at a rate not to exceed 0.2 gallons per square yard, as determined by the Engineer, over the specified low areas, and fill the low areas with No. 8 mineral aggregate. Seat the size No. 8 mineral aggregate with a pneumatic tire roller.

313.08 Tolerance in Pavement Thickness

Place treated permeable base to the thickness designated on the Plans. Before beginning any further work, take core samples from the treated permeable base, at locations established by the Engineer, in accordance with **501.24** for verification of base thickness. Take core samples at locations determined and witnessed by a Department representative, and document on the appropriate form.

The Department will make adjustments to the contract unit price in accordance with **501.26** if the base thickness is determined by the Engineer to be deficient.

COMPENSATION

313.09 Method of Measurement

The Department will measure treated permeable base by the square yards complete in place for the width and thickness specified.

313.10 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Treated Permeable Base	Square Yard

The Department will adjust payment in accordance with **501.26.B** for all base found to be deficient in thickness by more than 1/4 inch. The Department will not make additional payment over the contract unit price for base that has an average thickness in excess of that shown on the Plans.

If the Department orders any increase or decrease in the cement content of the Cement Treated Base from the approved mix design, the measurement and payment for this change will be computed in accordance with **501.25** and **501.26**.

The Department will consider the cost of taking cores for verification of pavement thickness to be included in the contract unit price of treated permeable base.

The Department will not allow additional compensation for leveling of the treated permeable base except on ramps that contain 4,500 square yards or less of Portland cement concrete pavement. The Department will measure and pay for additional concrete used on these ramps in accordance with **501.25** and **501.26**.

PART 4 – FLEXIBLE SURFACES

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SECTION 401 – MINERAL AGGREGATE SURFACE

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DESCRIPTION

401.01 Description

This work consists of furnishing and placing one or more courses of aggregates, and an admixture if required, on a prepared surface.

MATERIALS

401.02 Materials

Provide materials as specified in:

Aggregate, Class B **903.05.B**
Calcium Chloride, Type I, Type 2, or
Calcium Chloride Liquor **921.02**
Sodium Chloride **921.03**

The Engineer will accept aggregate for gradation as specified in **303.02**.

EQUIPMENT

401.03 Equipment

Provide equipment as specified in **303.05**.

CONSTRUCTION REQUIREMENTS

401.04 Construction Methods

Obtain the Engineer's approval of the completed roadbed before placing any surface material upon it.

On projects not requiring placement of surface material over the entire width of the roadbed, blade sufficient subgrade material from the subgrade, forming windrows on the shoulders from which to complete the compacted shoulders to the required cross-section after completing the surface course.

The surface course material may be spread with mechanical spreaders, dumped in windrows, or end dumped. Use approved machine methods to spread material dumped in windrows or end dumped, taking care to destroy all compaction planes caused by dumping or hauling over the material.

Construct the mineral aggregate surface in layers as shown on the Plans, with spreading, machining, sprinkling, and compaction operations progressing until the work is in reasonably close conformity to the lines, grades, and cross-sections shown on the Plans or established by the Engineer. Construct and maintain the surface of each layer so as to produce a uniform texture and to firmly key the aggregate. Uniformly apply water over the surface material during compaction in the amount necessary to ensure proper consolidation.

Roll each layer using approved rollers until the surface is thoroughly compacted and approved by the Engineer. If the required compacted depth of the surface course exceeds 6 inches, construct the surface course in two or more layers of approximately equal thickness. The maximum compacted thickness of any one layer shall not exceed 6 inches; however, if using vibrating or other approved types of special compacting equipment, the Contractor may increase the compacted depth of a single layer of the surface course to 8 inches with the Engineer's approval.

If two or more sizes or types of aggregates are to be blended on the road, spread the different aggregates separately using an approved mechanical spreader that can be adjusted to spread the materials in the proper proportions.

After spreading the material, and additive if specified, perform mixing using an approved mechanical mixer that is capable of producing a thorough and intimate mixture of aggregates, additive, and water.

Incorporate calcium chloride, if required, as specified in **303.08.B**.

401.05 Thickness and Surface Requirements

The thickness and surface of the completed Mineral Aggregate Surface shall meet **303.12** and **303.13**.

COMPENSATION

401.06 Method of Measurement

The Department will measure:

1. Mineral Aggregate Surface by the ton in accordance with **109**.

2. Water added to the materials at the direction of the Engineer by the M.G. (1,000 gallons) using calibrated tanks or distributors, or accurate water meters.

3. Calcium Chloride by the ton in accordance with **303.14.D**.

4. Sodium Chloride by the ton in accordance with **109**.

When measuring Mineral Aggregate Surface, the Department will deduct the weight of all surface moisture on the aggregate at the time of weighing in excess of 8%.

401.07 Basis of Payment

The Department will pay for accepted quantities of Mineral Aggregate Surface, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Mineral Aggregate	Ton
Calcium Chloride	Ton
Sodium Chloride	Ton
Water	MG

SECTION 402 – PRIME COAT

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402.07 Applying Cover Material 283
402.08 Maintenance and Protection 283
402.09 Method of Measurement 284
402.10 Basis of Payment 284

DESCRIPTION

402.01 Description

This work consists of applying bituminous material, and cover material if required, on a designated base.

MATERIALS

402.02 Materials

Provide materials as specified in:

Aggregate for Cover Material, Size 7, 8 or 78 ..... **903.13**
Emulsified Asphalt, Grade AEP or CAE-P **904.03**

Apply Emulsified Asphalt, Grade AEP or CAE-P, at a temperature range of 60 to 140 °F.

EQUIPMENT

402.03 Equipment

Provide a power broom or other mechanical sweeping equipment, bituminous heating equipment, a water sprinkler, a pressure distributor, and such other equipment and small tools as may be required to perform the work in a satisfactory manner.

The distributor shall be designed, equipped, maintained, and operated so that bituminous material at even heat may be applied uniformly on variable surface widths at readily determined and controlled rates from 0.2 to 0.5 gallons per square yard, with uniform pressure, and with an allowable variation from any specified rate of plus or minus 0.02 gallons per square yard.

Distributor equipment shall include: a tachometer, pressure gauges, accurate volume measuring devices, a calibrated tank, a thermometer for measuring the temperature of the material in the tank, a power unit for the pump, and full circulation spray bars that are adjustable laterally and vertically.

CONSTRUCTION REQUIREMENTS

402.04 Limitations

When applying bituminous prime coat, adhere to the same seasonal and temperature limitations as those specified for the succeeding stage of construction. The Contractor may apply the prime coat to a surface that is slightly damp, but never to a wet surface.

402.05 Preparing the Surface

Prepare the surface to be primed as specified in **303** or **310**, whichever is applicable.

If delays in the priming operation occur, maintain or rework the prepared surface to meet the requirements of **303** or **310**, whichever is applicable, before resuming the priming operation.

402.06 Applying Priming Material

Before applying the treatment, obtain the Engineer's approval of all areas to be treated. Apply and spread the bituminous material uniformly over the width of the section to be primed using a pressure distributor. The Engineer will designate the rate of application within the extreme limits shown on the Plans. Maintain the application temperatures within the ranges specified in **402.02**. To correct areas containing an excess or deficiency of priming material, add blotter material or bituminous material, as directed by the Engineer.

Protect all structures and concrete surfaces from the bituminous material during construction.

402.07 Applying Cover Material

If the bituminous material fails to penetrate before the time the roadway must be used by traffic, spread dry cover material at a rate established by the Engineer, between 8 and 12 pounds per square yard, to prevent damage to the primed surface. Avoid applying an excess of cover material.

402.08 Maintenance and Protection

Maintain the prime coat and the surface intact until it has been covered by the wearing surface or the project is completed. Do not place any succeeding stage of construction upon the prime coat until it has properly cured.

Repair spots where the prime coat may have failed, due to disintegration of the underlying surface material or other reasons, as follows:

1. Lightly dampen the exposed areas.

2. Refill such areas with approved material and thoroughly compact to conform with the surrounding surface.

3. Apply bituminous prime material to the surface with a hand spray.

If this method cannot produce satisfactory repairs, fill the depressions with approved mixtures of bituminous material and fine aggregate, and compact the mixture to conform to the surrounding surface.

COMPENSATION

402.09 Method of Measurement

The Department will measure:

1. Bituminous material and cover material by the ton in accordance with **109**.

2. Water used at the direction of the Engineer to dampen the base before applying bituminous materials by the M.G. (1,000 gallons), using calibrated tanks or distributors, or accurate water meters.

The Department may use net certified weights as a basis of measurement for cover material aggregate, subject to correction for aggregate that is lost, wasted, or otherwise not incorporated in the Work.

402.10 Basis of Payment

The Department will pay for accepted quantities of Prime Coat, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Bituminous Material	Ton
Cover Material	Ton
Water	MG

If the prime coat is damaged due to causes beyond the Contractor's control, the Department will pay, at the contract unit prices, for mineral aggregate and bituminous material used to repair the damaged areas as specified in **402.08**.

SECTION 403 – TACK COAT

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403.03 Equipment 286
403.04 Preparing the Surface 286
403.05 Applying Emulsified Asphalt 286
403.06 Method of Measurement 288
403.07 Basis of Payment 288

DESCRIPTION

403.01 Description

This work consists of furnishing and applying emulsified asphalt to a previously prepared base or surface course to provide bond for a superimposed course.

MATERIALS

403.02 Bituminous Materials

Provide materials as specified in:

Emulsified Asphalt, SS-1, SS-1h, CSS-1, CSS-1h, TST-1P, CQS-1h, CQS-1hp, TTT-1, TTT-2 ..... **904.03**

Apply tack coat at the temperature ranges specified in Table 403.02-1.

Table 403.02-1: Tack Coat Application Temperatures

Material	Temperature Range
SS-1, SS-1h, CSS-1, TST-1P, CQS-1h, CQS-1hp and CSS-1h	60 to 140 °F
TTT-1	160 to 180 °F
TTT-2	120 to 160 °F

Dilution of asphalt emulsion used for tack coat on hot mix asphalt paving projects after leaving the terminal is not allowed. Apply the emulsion as delivered from the terminal.

EQUIPMENT

403.03 Equipment

Provide a power broom, equipment for heating bituminous material, a pressure distributor meeting the requirements of **402.03**, and such other equipment and small tools as may be required to perform the work in a satisfactory manner.

403.04 Preparing the Surface

Prepare the designated surface as specified in **404.05**. Ensure that the surface is dry when applying tack coat.

403.05 Applying Emulsified Asphalt

A. Emulsified Asphalt

Immediately after cleaning the surface, apply emulsified asphalt with the pressure distributor at a rate, established by the Engineer, within the range of 0.05 to 0.10 gallons per square yard of applied emulsion. If the bituminous material is to be placed upon a milled surface, apply at a rate, established by the Engineer, within the range of 0.08 to 0.12 gallons per square yard of applied emulsion. When applying tack coat on freshly-placed asphalt, lower application rates may be permitted, provided a full coverage application is still achieved.

For slurry seal and microsurface, apply a tack coat of SS-1h, CQS-1h, or CQS-1hp emulsion. The tack coat shall consist of one part emulsion

and three parts water. The application rate shall be 0.10 to 0.15 gallons per square yard of the diluted emulsion. The Engineer will determine the actual application rate.

Protect the surfaces of trees and structures adjacent to the area being treated so as to prevent their being splattered or marred.

Allow the tacked surface to dry until it is in a proper condition to receive the next course. Apply tack coat only so far in advance of the paving operations as is necessary to obtain this proper condition of tackiness. Protect the tack coat from damage until the next course is placed.

B. Test Strip

When setting up an initial roller pattern and density test strip for the first layer of asphalt mixture, prepare a tack coat test strip to demonstrate that the proposed equipment and methods will achieve proper application of tack coat.

For the test strip, apply the tack material at a rate of between 0.05 and 0.10 gallons of applied emulsion per square yard. If placing the bituminous material upon a milled surface, apply the tack material at a rate of between 0.08 and 0.15 gallons of applied emulsion per square yard.

In all cases, ensure that the application will result in a minimum double overlap of the actual tack spray as it lands on the surface. Adjustment of the spray-bar and the nozzles may be necessary to achieve this minimum double overlap. Corn-rows or any other pattern that would result in less than double overlap coverage of the tack coat are not acceptable for the tack application. The goal is to have a very thin but uniform coating of asphalt left on the surface when the emulsion has broken.

Once the test strip has been demonstrated and approved by the Engineer, use the same procedure and application rates for the entire project or until another design is proposed and accepted.

C. Fog Sealing of Shoulders

When the Contract requires bituminous material for fog sealing of shoulders, provide emulsified asphalt meeting **403.02**. Apply diluted

emulsified asphalt at a rate of 0.10 to 0.15 gallons per square yard based on a dilution rate of one part emulsified asphalt to one part water. This application may require two equal increments if run-off occurs.

COMPENSATION

403.06 Method of Measurement

The Department will measure Emulsified Asphalt for Tack Coat and Fog Sealing by the ton, as delivered from the terminal, in accordance with **109**.

403.07 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Emulsified Asphalt for Tack Coat	Ton
Emulsified Asphalt for Fog Seal	Ton

The Department will measure and pay for the work required to prepare the designated surface, as provided for under **403.04**, in accordance with the applicable Section or Subsection under which the work is performed.

SECTION 404 – DOUBLE BITUMINOUS SURFACE TREATMENT

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404.08 Shoulders 292
404.09 Maintenance and Protection 292
404.10 Method of Measurement 293
404.11 Basis of Payment 293

DESCRIPTION

404.01 Description

This work consists of constructing, on a designated surface, a bituminous mat composed of mineral aggregate bonded with bituminous material.

MATERIALS

404.02 Materials

Provide materials as specified in:

Mineral Aggregate	**903.14**
Emulsified Asphalt, CRS-2p	**904.03**

Apply emulsified asphalt at a temperature range of 60 to 140 °F .

EQUIPMENT

404.03 Equipment

Provide a power broom or other mechanical sweeping equipment, equipment for heating bituminous material, a pressure distributor meeting the requirements of **402.03**, pneumatic-tire and steel-wheel rollers, self-propelled mechanical aggregate spreading equipment that can be adjusted so as to spread accurately at the specified rate, and such other equipment and small tools as may be required to perform the work in a satisfactory manner.

404.04 Limitations

Only apply bituminous material:

1. When the designated surface is dry, firm, and properly cured;
2. Between April 15 and October 1; and, unless otherwise directed,
3. When the ambient temperature in the shade and away from artificial heat is 70 °F or above.

404.05 Preparing the Designated Surface

The Plans will indicate whether the surface is to be constructed on a treated or untreated subbase, a granular base, an asphalt base, or on an existing surface. The surface of the base or sub-base upon which the construction is to be placed shall meet the requirements of the applicable Section of Part 3, Bases and Subgrade Treatments, of these Specifications.

Condition the existing surface, if called for on the Plans, as specified in **407.10**. Condition existing mineral aggregate base as specified in **310**.

Construct and maintain Prime Coat or Tack Coat, if shown on the Plans, as specified in **402** or **403**, respectively.

404.06 Applying Emulsified Asphalt and Mineral Aggregate

A. First Application

Apply the first application of emulsified asphalt using pressure distributors at a uniform rate established by the Engineer within the range of 0.30 to 0.38 gallons per square yard. Apply each spread of

bituminous material so as not to be more than 6 inches wider than the width covered by the immediate spread of cover aggregate. Each width of spread shall not be less than half the surface to be treated.

Before beginning each spread, place building paper across the roadway surface with the forward edge exactly coinciding with the end of the preceding covered spread. Start distributors on the paper, the width of which shall allow the full force of all nozzles to be in effect before the forward edge of the paper is reached. If required by the Engineer, also stop the spread on building paper. Remove the paper immediately after its use, and dispose of properly. Immediately correct all defects in application.

Treat areas that are inaccessible to the distributor with hand sprays or pouring pots as directed by the Engineer.

If treating less than the full width of the roadway, do not spread the aggregate on the inside 6 inches of either the first or second application until the adjacent lane has been treated. Immediately following each application, uniformly cover the applied bituminous material with Size No. 7 mineral aggregate that is reasonably free of surface moisture.

Spread the aggregate at a rate between 24 and 30 pounds per square yard, as established by the Engineer, using a self-propelled mechanical spreader; except on short projects of 1/2 mile in length or less, self-propelled mechanical spreading equipment will not be required. Back the truck on the aggregate being spread, without driving on or over uncovered bituminous material.

The length of bituminous material spread shall not exceed that which trucks loaded with cover material can immediately cover.

B. Second Application

Apply the second application of emulsified asphalt in the same manner as the first application, at a uniform rate established by the Engineer within the range of 0.20 and 0.35 gallons per square yard.

Spread mineral aggregate, Size No. 8, in the same manner as the first spread at a rate established by the Engineer within the range of 16 to 28 pounds per square yard.

Immediately after each spread of cover aggregate, broom to achieve uniform coverage. Use a power source, which is independent of the drive train that propels the equipment, to power the revolving brooms of mechanical sweeping equipment. Place additional aggregate by hand on thin or bare areas.

404.07 Rolling and Curing

Immediately after spreading and brooming the cover aggregate, roll the entire surface, beginning at the edges and progressing to the center. Begin rolling within 30 minutes after spreading the aggregate. Perform initial rolling with a self-propelled pneumatic tire roller, and follow with steel-wheel rolling. The amount and sequence of rolling shall be as directed by the Engineer.

Allow the first application of bituminous material and aggregate to cure for as long as deemed necessary by the Engineer before beginning the second application. Immediately before the second application of bituminous material, roll the surface with a steel-wheel roller.

For the second application of bituminous material and cover aggregate, repeat the same rolling and curing procedures as required for the first application.

The Contractor may allow slow-moving traffic to use sections of the roadway where the bituminous material has been covered with mineral aggregate.

404.08 Shoulders

Restore shoulders disturbed by the Contractor's construction operations at no cost to the Department. Remove all objectionable material placed on the shoulders by the Contractor as directed by the Engineer.

Construct shoulders, when specified, as provided for under **208**.

404.09 Maintenance and Protection

While the construction is in progress, maintain each completed section until the entire Project is complete. This maintenance shall include making repairs where failures occur; maintaining the surface in a smooth, uniform condition; and brooming, dragging, and rolling when required.

After the final application, maintain the work in a satisfactory condition for a period of at least 10 calendar days. If all other requirements of the Contract have been fulfilled, the Department will not charge working days against the Contract time during this maintenance period.

For final cleanup, sweep up all excessive quantities of loose, dislodged cover aggregate that may have collected along the edge of the completed surface treatment, and dispose of this material as directed by the Engineer.

COMPENSATION

404.10 Method of Measurement

The Department will measure Mineral Aggregate and Bituminous Material by the ton in accordance with **109**. The Department may use net certified weights as a basis of measurement for Mineral Aggregate, subject to correction for aggregate that is lost, wasted, or otherwise not incorporated in the Work.

404.11 Basis of Payment

The Department will pay for accepted quantities of Double Bituminous Surface Treatment, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Bituminous Material	Ton
Mineral Aggregate	Ton

The Department will measure and pay for the work required to prepare the designated surface, as provided for under **404.05**, in accordance with the applicable Section or Subsection under which the work is performed.

SECTION 405 – BITUMINOUS SEAL COAT

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405.10 Method of Measurement 298
405.11 Basis of Payment 298

DESCRIPTION

405.01 Description

This work consists of constructing a bituminous seal coat consisting of one or more applications each of bituminous material and cover aggregate.

MATERIALS

405.02 Materials

Provide materials as specified in:

Mineral Aggregate, Size Nos. 7, 8, 78, 89 ..... **903.13**
Emulsified Asphalt, CRS-2p **904.03**

Apply seal coat at a temperature range of 60 to 140 °F.

EQUIPMENT

405.03 Equipment

Provide equipment as specified in **404.03**.

CONSTRUCTION REQUIREMENTS

405.04 Limitations

Adhere to the limitations specified in **404.04**. If approved by the Engineer, the limitations for construction to be covered by a succeeding stage of pavement after October 1 and prior to April 15 shall be as follows:

Adhere to the seasonal limitations specified in **407.09**.

405.05 Preparing the Designated Surface

Prepare the surface to be sealed as specified in **404.05**.

405.06 Applying Bituminous Material

At least 14 working days before the scheduled start of construction of any bituminous seal coat, submit a sample of aggregate intended for use for the determination of the appropriate application rates of bituminous material and aggregate. Apply emulsified asphalt by pressure distributor at a uniform rate in accordance with Table 405.06-1 below. The exact rate will be established by the Engineer.

Table 405.06-1: Application Rates for Bituminous Material

Aggregate Size (per 903.22)	Aggregate Spread Rate (lb/yd^2)	Emulsion Shot Rate (gal/yd^2)
7	25 – 30	0.30 – 0.45
78	22 – 28	0.28 – 0.38
8	20 – 25	0.20 – 0.35
89	17 – 23	0.17 – 0.28

Before beginning each spread, place building paper across the roadway surface with the forward edge exactly coinciding with the end of the

preceding covered spread. Start distributors on the paper, the width of which shall allow the full force of all nozzles to be in effect before the forward edge of the paper is reached. If required by the Engineer, also stop the spread on building paper. Remove the paper immediately after its use, and dispose of properly. Immediately correct all defects in application.

The length of spread of bituminous material shall not exceed that which trucks loaded with cover material can immediately cover.

The spread of bituminous material shall not extend more than 6 inches wider than the width covered by the cover material. Do not allow the bituminous material to chill or otherwise impair retention of the cover material.

Do not allow traffic on the bituminous material until it has been covered with mineral aggregate.

Treat areas that are inaccessible to the distributor with either hand sprays or pouring pots as directed by the Engineer.

405.07 Spreading and Rolling Aggregate

A. Spreading

Spread and embed the mineral aggregate cover in the bituminous material. Spread the aggregate as close to the application of bituminous material as is practicable, and cover each distributor load applied immediately. Ensure that the mineral aggregate cover is reasonably free of surface moisture.

Spread the aggregate in accordance with the rates specified in Table 405.06-1. The exact rate will be established by the Engineer. Back the truck on the aggregate being spread, without driving on or over uncovered bituminous material. If treating less than the full width of roadway, do not spread the aggregate on the inside 6 inches of the bituminous spread until the adjacent lane is treated. Immediately after spreading the aggregate, perform hand-brooming to achieve uniform coverage. Place additional aggregate by hand on thin or bare areas.

B. Rolling

Immediately after distributing the aggregate, roll the entire surface by moving in a longitudinal direction, beginning at the outer edges and

progressing toward the center of the roadway, with each trip of the roller overlapping the previous trip by half the width of the rear wheel. Perform initial rolling with a self-propelled pneumatic tire roller, and follow with steel-wheel rolling. The amount and sequence of rolling shall be as directed by the Engineer. Complete the initial rolling of the aggregate within 1 hour after applying the bituminous material.

Use hand brooms to correct irregularities by sweeping the aggregates from areas of thick or heavy distribution to areas of thin or light distribution. Then continue rolling using both steel-wheel and pneumatic rollers until the aggregate is thoroughly embedded in the bituminous material. The Engineer may require additional rolling at a later date. Redistribute excess or loose aggregate that was thrown out of place.

Slow moving traffic may use the section or roadway upon which the aggregate has been spread.

405.08 Shoulders

Restore shoulders that have been disturbed by the Contractor's construction operations at no cost to the Department. Remove all objectionable material placed on the shoulders by the Contractor as directed by the Engineer.

Construct shoulders, when specified, as provided for under **208**.

405.09 Maintenance and Protection

Maintain in a satisfactory condition each completed section of seal coat until the entire Project is complete. Maintenance shall include making repairs where failures occur, and maintaining the seal coat in a smooth uniform condition.

After the final application, maintain the work in a satisfactory condition for at least 10 calendar days. If all other requirements of the Contract have been fulfilled, the Department will not charge working time during the 10-day maintenance period against the Contract time.

For final cleanup, sweep up all excessive quantities of loose, dislodged cover aggregate that may have collected along the edge of the completed seal coat, and dispose of this material as directed by the Engineer.

405.10 Method of Measurement

The Department will measure Mineral Aggregate and Bituminous Material by the ton in accordance with **109**. The Department may use net certified weights as a basis of measurement for mineral aggregate, subject to correction for aggregate that is lost, wasted, or otherwise not incorporated into the Work.

405.11 Basis of Payment

The Department will pay for accepted quantities of Bituminous Seal Coat, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Bituminous Material	Ton
Mineral Aggregate	Ton

The Department will measure and pay for the work required to prepare the designated surface, as provided for under **405.05**, in accordance with the applicable Section or Subsection under which the work is performed.

SECTION 407 – BITUMINOUS PLANT MIX PAVEMENTS (GENERAL)

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DESCRIPTION

407.01 Description

This Section 407 is applicable to all types of bituminous pavements of the asphalt plant mix type as described in **307**, **313**, and **411**. Deviations from these general requirements will be indicated in the specific requirements for each pavement type.

This work consists of constructing one or more courses of bituminous mixture on a prepared foundation in accordance with this Section **407** and the specific requirements of the pavement type under contract.

MATERIALS

407.02 Materials

Provide materials as specified in:

Aggregates	**903**
Mineral Filler	**903.16**
Bituminous Materials	**904**
Chemical Additive	**921.06.B**

Separate aggregate into coarse and fine aggregate stockpiles. If stockpiling of coarse aggregate causes segregation, separate into coarse and medium coarse stockpiles.

Store each size and type of aggregate in a separate pile, bin, or stall. Maintain the storage yard in an orderly condition, clearing a walkway between stockpiles that are not separated by partitions. Make the stockpiles readily accessible for sampling.

The Engineer will conditionally accept the mineral aggregate for quality in the stockpile at the producer's site. The Engineer may conditionally accept the bituminous material at the asphalt terminal. The Engineer will accept for aggregate gradation and asphalt cement content from hot bin samples or sample(s) taken from the completed mix at the asphalt plant after it has been loaded onto the trucks for transport to the Project.

If anti-stripping additive, other than hydrated lime, meeting **921.06.B.1** is required, use approved in-line blending equipment, as specified in **407.04.A.6**, to add it at the mixing plant or inject it at the asphalt terminal.

If the resurfacing plans call for a Performance Grade (PG) asphalt mix with properties greater than that of PG 64-22 and this is the only asphalt grade on the Project, the Contractor may use either the asphalt grade shown on the Plans or an asphalt grade equal to or better than PG 64-22 for driveways and business entrances unless otherwise directed by the Engineer. The Department will pay for this material at the same unit price as bid for the

asphalt or asphalt mix. Mark the material tickets "**FOR DRIVEWAYS AND BUSINESS ENTRANCES ONLY**" at the point of delivery.

If using a warm mix asphalt additive meeting **921.06.B.3**, use approved blending equipment to add it at the mixing plant, or deliver it premixed with the asphalt cement.

For 411-OGFC mixtures, include a stabilizing additive listed on the Department's Qualified Products List (QPL). Do not use fiber pellets. Slag wool fiber or cellulose fiber shall be blown into the asphalt plant measured by a flow meter or sensing device that is accurate to within ±10% of the amount required. For batch plants, add fibers in to the pugmill or weigh hopper. For drum plants, place the fiber line 1 foot upstream of the asphalt binder line so that the fibers are captured by the asphalt binder before being exposed to high-velocity gases in the drum. The minimum additive for a slag wool fiber shall be 0.4% and the minimum for a cellulose fiber shall be 0.3% of the total mix. The addition of a stabilizing additive material (fiber) shall be included in the cost of the asphalt cement.

407.03 Composition of Mixtures

A. General

Develop a bituminous mixture composed of aggregate (coarse, fine, or mixtures thereof), mineral filler if required, anti-strip additive if required, and bituminous material. Ensure that the aggregate fractions are sized, uniformly graded, and combined in such proportions so that the resulting mixture will meet the grading and physical properties of the approved Job Mix Formula (JMF).

B. Gradation and Bituminous Material Requirement

The requested aggregate gradation and bituminous material percentages shown on the JMF shall be within the design ranges specified in **903**, **307**, and **411**, respectively. Establish a recommended asphalt cement content for all mixes, with the final optimum asphalt cement content to be determined by the Engineer.

C. Job Mix Formula (JMF)

1. **General.** At least 14 working days before the scheduled start of production of any asphaltic paving mixture, submit a proposed Job Mix Formula (JMF) and Laboratory Design in electronic form,

where applicable, prepared in accordance with the Marshall Method of Mix Design (Asphalt Institute, MS-2), as modified by the Department, or by Gyratory Compaction (AASHTO T 312). Regardless of which method is used, prepare trial blends with at least four different asphalt contents (at least two above the optimum and two below the optimum).

When using the Marshall method of compaction, compact the specimens to 75 blows per side. When using the gyratory method of compaction, compact specimens to 65 gyrations.

All 411-OGFC design procedures shall follow the most current version of National Asphalt Pavement Association (NAPA) Publication IS-115, "Design, Construction and Maintenance of Open-Graded Friction Courses" except where modified herein. Design the OGFC using a Marshall compaction hammer at 50 blows or a standard gyratory compactor at 50 gyrations.

Provide the following information with JMF submittals:

a. The specific project on which the mixture will be used.

b. The source and description of all materials to be used in the mix.

c. The gradations and approximate proportions of the raw materials as intended to be combined in the paving mixture.

d. A single percentage of the combined mineral aggregate passing each specified sieve. Plot the combined aggregate gradation on a gradation chart with sieve sizes raised to the 0.45 power to ensure a well graded mix.

e. The Loss on Ignition (L.O.I.) results on the combined aggregate of the mixture used as a wearing course.

f. The Bulk Specific Gravity, Apparent Specific Gravity, and absorption on the combined mineral aggregate in the paving mixture (AASHTO T 84 and T 85)

g. The fractured face count and glassy particle count of the plus No. 4 material, if applicable.

h. A single percentage of asphalt by weight of total mix intended to be incorporated in the completed mixture.

i. The dosage rate and source of anti-stripping additive, if required, meeting the requirements of **921.06.B.1**, to be added to the asphalt.

j. The maximum specific gravity of the asphalt mixture (AASHTO T 209).

k. A single temperature at which the mixture is intended to be discharged from the plant.

l. Evidence that the completed mixture will conform to all physical requirements specified in **903.06** and **307.03.A** or **903.11** and **411.03.B**; however, for mixes designed according to AASHTO T 312, the stability and flow requirements will be waived and the resistance to rutting requirements for surface mixtures must be met.

m. The tensile strength ratio (TSR) indicating the stripping and moisture susceptibility characteristics of the mix.

n. To identify critical mixes and make appropriate adjustments, the mix design shall meet the required design properties for stability, flow, voids in mineral aggregate (VMA), and production void content as specified in **307.03** and **411.03** at the bitumen content range of Optimum Asphalt Cement ±0.25%.

Establish the laboratory mix and compaction temperatures for the JMF in accordance with Table 407.03-1.

Table 407.03-1: Laboratory Mix and Compaction Temperatures

PG Binder Grade	Lab Mix Temperature (°F)	Lab Compaction Temperature (°F)
64-22, 67-22	Per temp./visc. chart	Per temp./visc. chart
70-22	320 – 345	295 – 320
76-22	320 – 345	305 – 330
82-22	320 – 345	305 – 335

Perform any additional laboratory testing of the mix using the laboratory mix and compaction temperatures listed on the approved JMF, with a tolerance of ± 5 °F for each temperature.

A Certified Laboratory Technician shall prepare and sign the Laboratory Design. To be certified, the technician shall have completed the Marshall Method of Mix Design School conducted by the Department, including the written and lab performance testing.

2. **Revision of Job Mix Formula.** The approved JMF shall remain in effect until the Engineer authorizes a change in writing. The Contractor, at any time after construction has started, may request that the JMF be revised, provided evidence is shown that the revision is necessary and the revised aggregate gradation will meet all applicable gradation requirements.

   Submit a revised JMF if, during the test strip construction and mix design/production verification procedure, changes are made to the mixture to comply with the specified criteria.

   Provide a new design for any change in source of materials.

   Submit all requests for design mix adjustments, redesigns, and new design mixes in writing to the Engineer for approval.

3. **Resistance to Plastic Flow.** Include, with the submitted JMF, test data showing that the material as produced will meet **307.03.A** or **411.03.B** when tested according to AASHTO T 245. Determine the bulk specific gravity of the laboratory compacted bituminous mixture (Marshall specimens) according to AASHTO T 166.

Mixes designed according to AASHTO T 312 are exempt from AASHTO T 245.

For surface mixtures used on roads with greater than 5,000 ADT, designed with the gyratory compactor (AASHTO T 312), include sufficient raw materials (aggregate and asphalt cement) with the submitted JMF so that the Central Laboratory may conduct rut testing in accordance with AASHTO T 340. The maximum allowable rut depth shall be 0.35 inches for roads with greater than or equal to 10,000 ADT and 0.40 inches for roads with 5,000 to 10,000 ADT.

Base the percent voids in the total mix on the maximum specific gravity of the bituminous mixture (Rice Gravity) according to AASHTO T 209. Calculate the voids in mineral aggregate (VMA) using the effective specific gravity of the aggregates.

D. Contractor's Quality Control

1. General. Assume responsibility for the quality of construction and materials incorporated in the Work. Provide and maintain a quality control system that will provide reasonable assurance that all materials conform to specification requirements.

Conduct all quality control sampling and testing according to the approved Quality Control Plan and the Department's Policies on Sampling and Testing Procedures and Sampling of Asphalt Mixes for Verification of Laboratory Design. The requirements for the Contractor's quality control sampling and testing will remain in effect until final Project acceptance.

2. Contractor Quality Control System. Develop, implement, and maintain a quality control system that will provide reasonable assurance that all materials and products submitted to the Department for acceptance conform to the specified requirements.

a. Quality Control Technician. Ensure that a Quality Control Technician, who is currently certified by the Department as a Certified Asphalt Plant Technician, is present at the asphalt plant during mix production. If the Department finds that the Quality Control Technician cannot perform as required by the position, the Department will revoke the certification and require replacement with a certified technician.

b. Documentation. Document all quality control procedures, inspections, and tests and make this information available for review by the Department throughout the life of the Contract. Maintain adequate records of all inspections and tests. The records shall indicate the nature and number of tests performed, the number and type of deficiencies found, and the nature of corrective action taken as appropriate.

The Contractor's documentation procedures will be subject to the review and approval of the Department before the start of the work and to compliance checks during progress of the work. Provide copies of all charts and records documenting quality control tests and inspections to the Engineer on a daily basis.

c. Charts and Forms. Record all conforming and nonconforming inspections and test results on approved forms and charts, and keep these records current and complete. Maintain test results at the Contractor's plant site laboratory and make such records available to the Engineer at all times during the performance of the work. Chart test results for the various materials and mixtures on forms that meet the Engineer's requirements. Provide an example of each proposed chart and form to the Engineer. Supply all charts and forms to be used to record results.

d. Corrective Actions. Promptly correct all errors, equipment malfunctions, process changes, or other assignable causes that have resulted or could result in the submission of materials, products, and completed construction that do not conform to the specifications.

If the Engineer finds that the Contractor is not controlling its process and is making no effort to take corrective actions, the Engineer will require that plant operations be ceased until the Contractor can demonstrate that it can and will control the process.

e. Laboratories with Measuring and Testing Equipment. Provide a fully equipped laboratory at the production site as specified in **106.06**. This facility may be permanent or portable. Furnish the laboratory with the necessary testing equipment and supplies for performing Contractor Quality

Control sampling and testing as well as Department Acceptance sampling and testing. To assure accuracy, the Department will check the testing equipment periodically according to the Department's Procedure for Qualified Laboratories.

f. Sampling and Testing. Sampling and testing methods and procedures to determine quality conformance of the materials and products shall be in accordance with **106.04**. Address in the Quality Control Plan the taking of samples for material characteristics and the plotting of the test results on control charts.

g. Alternative Procedures. The Engineer may approve the use of alternative sampling methods, procedures, and inspection equipment if such procedures and equipment provide, as a minimum, the quality assurance required by the Contract. Before applying such alternative procedures, describe them in a written proposal and demonstrate, for the Engineer's approval, that their effectiveness is equal to or better than the Contract requirements.

h. Mix Design/Production Verification. After the JMF has been approved, provide material that conforms to the approved JMF within the acceptance range specified in Table **407.20-2**. Consider the process to be out of control and cease plant operations if test results from a lot fall below the 90% pay factor limit for the values specified in Table **407.20-2**. The Contractor may resume plant operations upon demonstrating that it can and will control the process.

Sample and test asphaltic concrete base and surface mixes throughout production to verify that the mix being produced is within the criteria specified in Table 407.03-2. Also record such information on control charts. Note that this requirement applies only to mixes designed according to the Marshall Method of Mix Design.

With the exception of any individual mix of 1,000 tons or less, meet the requirements specified in Table 407.03-2 for all interstate projects, any project with a current Average Daily Traffic (ADT) exceeding 12,000, and any project utilizing modified asphalt cements.

Table 407.03-2: Mix Design Requirements

Property	Value
Maximum Theoretical Gravity	± 0.025 of Mix Design Value
Voids in Total Mix	As noted for production in **307.03** and **411.03**
Voids in Mineral Aggregate	Minimum as noted in **307.03** and **411.03**
Marshall Stability	Minimum as noted in **307.03** and **411.03**
Dust/Asphalt Ratio	As noted in **307.03** and **411.03**

The asphalt pavement mix design/production verification procedure shall consist of the following:

(1) Submit mix designs to the Engineer for approval before mix production. Once approved, produce sufficient mix to construct a test strip as specified in **407.15.C**.

(2) Perform maximum theoretical gravity and gradation tests from material produced for constructing the test strip. A Quality Control Technician, who is currently certified by the Department as a Certified Asphalt Mix Design Technician, shall perform these tests under the Engineer's observation.

(3) Place no more than 500 tons of mix until the verification testing, with the exception of TSR, is complete. Without complete test results, the Contractor, at its risk, may continue to produce and place mixture in excess of the first 500 tons; however, all mixture will be subject to price adjustment or removal at the discretion of the Engineer if the test results do not comply with the specifications.

If the test results for the produced mix are within the limits required for production, as specified in Table 407.03-2, and mix density requirements are met, the Contractor may proceed.

If not, prepare a revised design before start up and submit to another evaluation process for the revised design. Place no more than 100 tons of mix during this trial. Repeat this process until an acceptable mix can be produced. All test strip and mixture design/production verification material will be subject to applicable price adjustments or removal at no cost to the Department. If the tensile strength ratio (TSR) results are not in compliance with the specifications, immediately stop production until mixture adjusts are made.

(4) During construction, perform verification testing, for each half-day's production, for mix quality control. Use a random numbers table to determine when to collect samples for testing.

(a) When the test results are outside the allowable criteria, immediately obtain a subsequent sample and test it for compliance.

(b) If the subsequent test results are within allowable limits, the Contractor may continue mix production.

(c) If the subsequent test results are outside allowable limits, do not resume mix production until it can be demonstrated to the Engineer that adequate corrective action has been taken. The Contractor may then produce sufficient mix, not to exceed 100 tons, to provide a representative sample for determining stability, voids in the total mix, and the dust/asphalt ratio. Do not continue with mix production until test results indicate compliance with Table 407.03-2 and the specified density.

3. Quality Control Plan. At the beginning of each paving season, submit in writing the proposed Quality Control Plan for the Engineer's approval. Include in this plan the sampling, testing, and inspection activities, and the anticipated frequencies of each, which the Contractor will follow to maintain process control. This Quality Control Plan shall apply to all Department contracts for the

calendar year. If a change is made to the Quality Control Plan during the year, communicate such changes to the Regional Materials Supervisor. Refer to the recommended series of sampling, testing, and inspecting activities shown in Table 407.03-3.

Table 407.03-3: Recommended Items for a Contractor Quality Control Plan

A. All Types of Plants

1. Stockpiles
   a) Determine gradation of all incoming aggregates.
   b) Inspect stockpiles for separation, contamination, segregation, etc.
   c) Conduct a fractured face count when gravel is used as coarse aggregate.
   d) Determine the percent of glassy particles in slag coarse aggregate.
   e) Determine gradation and asphalt content of reclaimed asphalt pavement when used as a component material.
2. Cold Bins
   a) Calibrate the cold gate settings.
   b) Observe operation of cold feed for uniformity.
   c) Ensure that bins have proper dividers to prevent materials from spilling over into adjacent bins.
3. Dryer
   a) Observe pyrometer for aggregate temperature control.
   b) Observe efficiency of the burner.
   c) Determine the percent dust coating on plus 4 material.
   d) Check dried aggregate for contamination due to incomplete combustion of fuel.
4. Hot Bins
   a) Determine gradation of aggregates in each bin.
   b) Determine theoretical combined grading.
5. Bituminous Mixture
   a) Determine percent bitumen.
   b) Determine mix gradation.
   c) Check mix temperature.
   d) Determine percent moisture in mix when reclaimed

asphalt pavement is a component material. e) Determine Loss-On-Ignition (LOI) of aggregates in mix where applicable. f) Check the mix for uncoated aggregate. g) Ensure that handling procedures do not contribute to segregation of the mix.
B. Batch Plants 1. Batch Weights – Determine percent used and weight to be pulled from each bin to assure compliance with the JMF. 2. Check mixing time (both dry and wet). 3. Check operations of weigh bucket and scales. 4. Document accuracy of all weighing and metering devices for: a) Asphalt cement b) Aggregate c) Anti-strip additive
C. Drum Mixer Plant 1. Calibrate the cold feed and prepare a calibration chart for each cold gate. 2. Develop information for the synchronization of the aggregate feed and the bituminous material feed. 3. Determine moisture content of aggregate being fed into dryer. 4. Determine the percent dust coating on dried plus 4 material. 5. Check dried aggregate for incomplete combustion of fuel. 6. Document accuracy of all weighing and metering devices for: a) Asphalt cement b) Aggregate c) Anti-strip additive

Consider the activities identified in Table 407.03-3 to be normal activities necessary to control the production of asphalt concrete at an acceptable quality level. However, note that depending on the type of process or materials, some of the activities listed may not be necessary, and in other cases, additional activities may be

required. The frequency of these activities will also vary with the process and the materials. When the process varies from the defined process average and variability targets, increase the frequency of these activities as necessary to restore proper conditions.

Plot and keep up-to-date control charts for all Quality Control Sampling and Testing. Provide control charts for the following:

(a) Extracted asphalt content

(b) Mix gradation

(c) Dust to asphalt ratio

(d) Maximum theoretical gravity (when required)

(e) Voids in total mix (when required)

(f) Stability (when required)

Post all current control charts in the asphalt lab where they can be seen.

The Contractor is responsible for formulating all design mixes with the exception of plant mix seal coat mixes. No lab design is required for **307** Grading A, AS, and ACRL mixes. However, establish the anti-strip additive dosage rate and verify compatibility of mixture materials by the ten minute boil test as specified in **407.03.E.2**. Submit all Contractor-furnished design mixes to the Department for approval prior to their use. Provide process control of all materials during handling, blending, mixing, and placing operations.

If reclaimed asphalt pavement (RAP) is approved for use as a component material in a hot bituminous mixture, the Contractor's Quality Control Plan shall include determination of the gradation and asphalt content of the RAP material at a minimum frequency of 1 stockpile sample per 2,000 tons used in the mixture.

E. Testing Procedures

Conduct the Tensile Strength Ratio (TSR), Stripping, and Loss on Ignition (LOI) testing in accordance with the following:

1. Tensile Strength Ratio. Perform testing for stripping and moisture susceptibility of the mixture according to ASTM D 4867, Standard Test Method for Effect of Moisture on Asphalt-Concrete Paving Mixtures (Root-Tunnecliff Procedure).

Specimen tested for stripping and moisture susceptibility according to Root-Tunnecliff Procedures shall meet the criteria specified in Table 407.03-4.

Table 407.03-4: Criteria for Stripping and Moisture Susceptibility

Asphalt Cement	Minimum Tensile Strength	Minimum TSR
Polymer Modified	100 psi	80%
Non-Polymer Modified	80 psi	80%

2. Ten Minute Boil Test (Stripping)

a. Field Test. Test the completed mix for stripping at the asphalt plant as follows:

(1) From a sample of the completed mix, visually select a minimum of 50 grams of the plus No. 4 material and place immediately in boiling water.

(2) Continue to boil for 10 minutes, pour off water, and place coated aggregate on a paper towel.

(3) Perform a visual inspection to verify that the coated aggregate shows no evidence of stripping.

b. Laboratory Test. Determine the dosage rate for anti-stripping additive in the laboratory as follows:

(1) Wash and surface dry 50 grams of the mineral aggregate passing the 1/2-inch sieve and retained on the No. 4 sieve.

(2) Thoroughly coat the selected aggregate with the blend by stirring the mixture heated to 250° F.

(3) Immediately place the material in boiling water.

(4) Continue to boil for 10 minutes, pour off water, and place coated aggregate on a paper towel.

(5) Perform a visual inspection to verify that the coated aggregate shows no evidence of stripping.

3. Test for Percent Loss on Ignition (LOI) of the Mineral Aggregate in an Asphalt Paving Mixture.. Conduct Loss on Ignition Testing as follows:

a. Obtain a representative aggregate sample and weigh approximately 600 grams into an assayer's fire clay crucible that has been ignited to constant weight. Place a cover on the crucible to prevent pop-out of aggregate while heating.

b. Ignite the covered crucible and its contents in a muffle furnace at 1742° F to constant weight (minimum of 8 hours).

c. Cool the crucible and contents to room temperature and weigh.

If the aggregate sample is obtained by extraction with a vacuum extractor, correct the weights before and after ignition for filter aid using the following equation:

$$\text{Percent loss on ignition} = \frac{(A - B) \times 100}{A}$$

Where:

A = weight of sample before ignition (corrected for filter aid)
B = weight of sample after ignition (corrected for filter aid)

EQUIPMENT

407.04 Bituminous Mixing Plant

Provide sufficient storage space for each size aggregate. Keep the different sizes separated until they have been delivered to the cold elevator or belt feeding the dryer. Maintain the storage yard in a neat and orderly condition and ensure that the separate stockpiles are readily accessible for sampling.

Plants used to prepare bituminous mixture shall meet all requirements specified in **407.04.A**. In addition, batch mixing plants shall meet **407.04.B**, continuous mixing plants shall meet **407.04.C**, and dryer-drum mixing plants shall meet **407.04.D**.

A. Requirements for All Plants

Mixing plants shall be of sufficient capacity and so coordinated to adequately handle the proposed bituminous construction.

1. **Equipment for Preparing Bituminous Material.** Provide tanks that are equipped to heat and hold bituminous material at the required temperatures. The circulating system for the bituminous material shall be designed to ensure proper and continuous circulation during the operating period. Make provisions for measuring and sampling the storage tanks' contents.

2. **Feeders for Dryer.** For each size aggregate, provide separate feeders that can deliver the aggregates onto the belt going to the dryer in proper proportions. Use mechanical feeders with separate adjustable gates to feed each size aggregate onto the belt.

   Provide adequate means to ensure a constant and uniform flow of material from each bin. Equip bins containing fine aggregate with vibrators if necessary.

   Do not blend or mix different aggregates, or different sizes of the same aggregates, with clam shells, bulldozers, high lifts, or similar equipment.

   Feed the aggregate into the dryer so as to obtain a uniform production and uniform temperature.

3. Dryer. The plant shall include a dryer or dryers that are capable of:

a. agitating the aggregate continuously during the heating and drying process;

b. heating and drying all aggregates to the temperature required, and

c. supplying the mixing unit continuously at its operating capacity.

Ensure that dryers are constructed and operated so that aggregates will not be contaminated with unburned fuel.

4. Screens. Provide plant screens, capable of screening all aggregates to the specified sizes and proportions and having normal capacities in excess of the mixer's full capacity.

The Contractor may allow a consistent carry-over, not to exceed 20%, on any screen. If any bin contains more than 20% of material that is undersized for that bin, empty the bin and correct the cause of this condition.

Provide approved scalping screens on all dryer-drum mixing plants; additional screens will not be required.

5. Bins. Provide storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Arrange bins to ensure separate and adequate storage of appropriate fractions of the mineral aggregates. For each bin, provide overflow pipes of the size and at the location needed to prevent material from backing up into other compartments or bins. Provide each compartment with an outlet gate constructed so that, when closed, no leakage occurs. The gates shall be cut off quickly and completely. The bins shall be constructed to provide adequate and convenient approved facilities for obtaining representative samples of aggregate from the full flow of each compartment. These bins are not required in an approved Dryer-Drum Mixing Plant. When using mineral filler, provide separate dry storage and equip the plant to uniformly and accurately feed the filler into the mixer.

6. **Bituminous Control Unit and Anti-Stripping Additive (ASA) Systems.** Provide means for weighing or metering the bituminous material to ensure the proper amount of material is added to the mix within the tolerance specified. Provide means for checking the quantity or rate of flow of bituminous material into the mixer.

   Where required, use approved in-line blending equipment to add anti-stripping additive, other than hydrated lime, meeting **921.06.B**. Provide a storage tank for the ASA that can maintain a constant temperature without overheating the additive. Store the additive according to the manufacturer's recommendations and at a temperature of 150 ºF or less. The in-line blending equipment on drum plants shall have a totalizing "flow meter" capable of measuring the actual flow rate within the production range of 0.00 to 1.00 gallons per minute at increments of 0.05 gallons. Batch plants shall have a totalizing flow meter that displays the total gallons of material dispensed. The dispenser and/or pumps shall be capable of adding the heat stable ASA within a tolerance of 10% of the specified rate.

7. **Thermometric Equipment.** Fix an armored thermometer, capable of reading an adequate temperature range, in the bituminous feed line at a suitable location near the charging valve at the mixer unit.

   At the discharge chute of the dryer, also place an approved thermometric instrument that can register automatically or indicate the temperature of the heated aggregates. With the Engineer's approval, the Contractor may place the thermometric instrument within the fines bin.

   Equip the plant with an approved automatic recording and regulating apparatus to control the temperature of the aggregates.

8. **Dust Collector.** Equip the plant with a dust collector constructed to uniformly waste or return to the dried aggregate all or any part of the material collected. Handle collected baghouse fines intended for recirculation into the mix as if it were mineral filler or feed by another suitable method approved by the Engineer. Provide means to calibrate and adjust the dust fed from a baghouse.

9. **Safety Requirements.** Provide adequate and safe stairways to the mixer platform and sampling points. Place guarded ladders to other plant units at all points requiring access to plant operations. Provide access to the top of truck bodies by a platform or other suitable device to allow the Engineer to obtain samples and mixture temperature data. Provide a hoist or pulley system to raise scale calibration equipment, sampling equipment, and other similar equipment from the ground to the mixer platform and return. Guard and protect all gears, pulleys, chains, sprockets, and other dangerous moving parts. Provide ample and unobstructed space on the mixing platform. Maintain a clear and unobstructed passage at all times in and around the truck loading area. Keep this area free of drippings from the mixing platform.

10. **Field Laboratory.** Provide a Type B field laboratory as specified in **106.06**.

11. **Surge and Storage Systems.** The Contractor may use surge and storage systems if the Department approves each system before use, and if the systems are designed to limit differences between material discharged from the bin or silo and material discharged directly from the plant.

    Equip the surge bins and storage silos with low and high mix level indicators. Place the low level indicator at a location on the bin or silo that has been predetermined to prevent segregation of the mix.

    Arrange the conveyor system used with the surge bins or storage silos so that samples of the mix or dry material may be conveniently taken.

    Ensure that storage silos are closed, insulated, and heated so as to prevent localized heating. The storage silo shall be capable of being sealed to prevent oxidation of the mixture. Equip surge bins with a rain cover capable of preventing water from entering the mix in the bin.

    The Engineer will base approval of a surge or storage system on inspection and tests that indicate that the system is capable of conveying, retaining, and delivering the bituminous mixture:

    a. Within the tolerance ranges as set forth on the JMF;

b. Without segregation; and

c. Without balling or hardening.

The Engineer may withdraw approval of a surge or storage system if tests, inspections, or both indicate that the system is having a detrimental effect on the bituminous mixture.

The Engineer will reject bituminous mix found to be damaged in any way by the use of a surge or storage system.

Mount, under the loading hopper, platform truck scales that meet the requirements of **109** and that are capable of recording tare and gross weights.

12. Warm Mix Asphalt Process Equipment. The Contractor may modify plants to reduce production and placement temperatures as specified in **407.11.B**. Obtain the Department's approval before making plant modifications for warm mix asphalt production temperatures. Modifications shall not impair the plant's ability to maintain temperature control or mixture proportions.

Ensure that modifications made to the plant to reduce mixing temperatures meet the requirements listed for warm mix asphalt additives in the Department's Qualified Products List (QPL).

B. Requirements for Batching Plants

1. Plant Scales. Provide dial scales for weighing of all aggregates and mineral filler, in the suspended weigh box. Dial scales shall be of a standard make and of sufficient size to allow the numerals on the dial to be read at a distance of 25 feet. The dials shall be of the compounding type having a full complement of index pointers. The value of the graduation of scales shall be as specified in Table 407.04-1.

Table 407.04-1: Graduation of Scales

Aggregate Amount (pounds)	Scale Graduation
< 5,000	≤ 5 pounds
5,000 to 10,000	≤ 10 pounds
> 10,000	≤ 0.1% scale capacity

Do not use pointers that give excessive parallax errors. Locate dial scales to be in plain view of the operator at all times. When bituminous material is measured by weight, equip the asphalt weigh bucket with a separate dial scale with a minimum graduation not greater than 2 pounds. All dial scales shall be accurate within a tolerance of 0.5%. Eliminate vibration by setting the scales on a separate foundation, if required. Provide each installation of scales with ten standard 50-pound weights meeting the requirements of the U.S. Bureau of Standards for calibrating and testing weighing equipment. Inspect scales as often as the Engineer deems necessary to ensure their continued accuracy.

Provide an approved automatic printer system that will print the weights of the material delivered, when the system is used in conjunction with an approved automatic batching and mixing control system. Provide a weigh ticket for each load as evidence of such weights.

2. **Weigh Box or Hopper.** Provide means for accurately weighing each size of aggregate and mineral filler in a weigh box or hopper suspended on scales. The weigh box or hopper shall be of ample size to hold a full batch without hand raking or running over. The gate shall close tightly so that no material can leak into the mixer while a batch is being weighed.

3. **Bituminous Control.** Provide a bituminous material bucket of a non-tilting type. The length of the discharge opening or spray bar shall be not less than 3/4 the length of the mixer, and it shall discharge directly into the mixer. The bituminous material bucket, its discharge valve or valves, and spray bar shall be adequately heated. Steam jackets, if used, shall be efficiently drainable and all connections shall be so constructed that they will not interfere with the efficient operation of the bituminous scales. The capacity of the bituminous material bucket shall be at least 15% in excess of

the weight of bituminous material required in any batch. Provide the plant with an adequately heated, quick-acting, non-drip, charging valve located directly over the bituminous material bucket. If the bituminous material is metered, the indicator dial shall have a capacity of at least 15% in excess of the quantity of bituminous material used in a batch. The meter indicator dial shall have a scale with divisions measuring in gallons equivalent to a weight sensitivity of 0.04% of the total batch weight. The meter shall be accurate within a tolerance of 0.5%. The controls shall be capable of being locked at any dial setting and automatically resetting to that reading after the addition of bituminous material to each batch. The dial shall be in full view of the mixer operator. Automatically control the flow of bituminous material so that it will begin when the dry-mixing period is over. All of the bituminous material required for one batch shall be discharged 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 bituminous material the full length of the mixer. Provide the section of the bituminous line between the charging valve and the spray bar with a valve, and provide the spray bar with a valve and outlet for checking the meter when a metering device is substituted for a bituminous material bucket.

4. **Mixer.** Provide an approved twin pugmill type mixer, steam or hot oil jacketed, that is capable of producing a uniform mixture within the job mix tolerances and that is constructed to prevent leakage of its contents. Equip the mixer with a sufficient number of paddles or blades set in the "run around" order, and operate at such speed as to produce a properly and uniformly mixed batch. The depth of the material in the pugmill shall not be above the tips of the paddles. If not enclosed, equip the mixer box with a dust hood to prevent loss of dust.

   The clearance of blades from all fixed and moving parts shall not exceed 1 inch unless the maximum diameter of the aggregate in the mix exceeds 1-1/4 inches, in which case the clearance shall not exceed 1-1/2 inches.

5. **Control of Mixing Time.** Equip the mixer with an accurate time lock to control the operations of a complete mixing cycle. It shall lock the weigh box gate after the charging of the mixer until the closing of the mixer gate, at the completion of the cycle. It shall lock the bituminous material 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 time interval between the opening of the weigh box gate and the start of introduction of bituminous material. The wet-mixing period is the time interval between the start of introduction of bituminous material and the opening of the mixer gate. The control of the timing shall be flexible and capable of being set at intervals of 5 seconds or less throughout a total cycle of up to 3 minutes. As a part of the timing device, install a mechanical batch counter that is designed to register only batches that have been mixed for the full time interval. Set the time intervals in the presence of and at the direction of the Engineer, who will then lock the case covering the timing device until a change is needed in the timing periods.

6. **Operator's Platform Observation House.** Equip the plant with a scale observer's house, mounted on or near the weigh platform and situated so that the aggregate and asphalt scales, asphalt thermometer, and pyrometer are plainly visible from within the house.

   Using approved materials, soundly construct the house to have at least 45 square feet of floor space and to be air conditioned by a unit of at least 12,000 Btu. The Contractor may install all batch controls in the house. However, do not use the house for storage or purposes other than to house the batch controls, plant operator, and Department Inspector. If choosing not to move the plant controls into the house, situate it so as to provide the scale inspector with a full view of the control panel.

   If the scale-observer's house is located on the asphalt plant, provide an adequate secondary means of escape in the event of fire or explosion.

   The Department will consider the house to be part of the plant and will not directly pay for its construction and maintenance.

C. Requirements for Continuous Mixing Plants

1. **Aggregate Proportioning.** Provide the plant with means for accurately proportioning each size of aggregate. 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 measuring volumetrically the material

drawn from each compartment. Equip bins with adequate tell-tale devices to indicate the position of the aggregates in the bins at the lower quarter points.

The feeding orifice shall be rectangular with one dimension adjustable by positive mechanical means provided with a lock. Provide indicators for each gate to show the respective gate opening in inches.

Ensure that mineral filler can be fed into the mixer continuously and uniformly in the proportion set out in the JMF, and in a manner satisfactory to the Engineer.

2. **Weight Calibration of Aggregate Feed.** Equip the plant with an approved revolution counter that is in satisfactory working condition. Provide means to calibrate gate openings by weighing test samples. Make provisions so that materials fed out of individual orifices may be bypassed to individual test boxes. Equip the plants to handle individual test samples weighing not less than 200 pounds. Provide accurate scales to weigh such test samples.

3. **Synchronization of Aggregate Feed and Bituminous Material Feed.** Provide positive interlocking control between the flow of aggregate from the bins and the flow of bituminous material from the meter or other proportioning device. This control may be achieved using mechanical means or any other positive method satisfactory to the Engineer.

4. **Mixer.** Provide a continuous mixer of an approved twin pugmill type, which is adequately heated and capable of producing a uniform mixture within the job mix tolerances. The paddles shall be adjustable for angular position on the shafts and reversible to retard the flow of the mix. The mixer shall have a manufacturer's plate indicating the net volumetric contents of the mixer at the several heights inscribed on a permanent gauge. Provide charts showing the rate of feed of aggregate per minute for the aggregate being used. Determine the mixing time by the weight method, using the following formula (with weights determined for the job using tests conducted by the Engineer) where:

$$\text{Mixing time in seconds} = \frac{\text{Pugmill dead capacity in pounds}}{\text{Pugmill output in pounds per second}}$$

5. **Surge Hopper.** Equip the mixer with a discharge hopper with dump gates that will allow rapid and complete discharge of the mixture and of such size and design that no segregation of the mixture occurs.

6. **Platform Truck Scales.** Platform truck scales shall meet the requirements of **109**.

D. Requirements for Dryer-Drum Mixing Plants

1. **Control of Aggregate.** Stockpile and handle aggregates so as to prevent any significant amount of segregation, contamination, or degradation. Construct stockpiles as specified in **903.20**.

   Each aggregate shall have a separate feeder with a positive feed that can be easily and accurately calibrated. Provide a flow indicator and an audible warning device on each separate feeder to ensure a constant and uniform flow of aggregate from each bin onto the belt.

   Feed mineral filler, if required, into the mixer continuously and uniformly in the proportion set out in the JMF and in a manner approved by the Engineer.

2. **Synchronization of Aggregate Feed and Bituminous Material Feed.** Provide satisfactory means to allow a positive interlocking control between cold aggregate feed and asphalt. Base the control setting for the asphalt flow on the dry weight of the aggregate. Provide an acceptable method for proportioning asphalt flow as variations in aggregate flow take place. Provide a metering system to measure the flow of asphalt into the drum, and locate an approved method of checking and calibrating the metering system in the control house. Provide an automatic interlock system that will shut off the asphalt flow and the burner when the aggregate flow ceases.

3. **Temperature Control.** Provide dryer-drum mixing plants equipped with a recording pyrometer or other approved thermometric instrument sensitive to a rate of temperature change of not less than 10 °F per minute. The system shall be equipped with automatic burner controls and shall provide for temperature sensing of the bituminous mixture at discharge from the drum.

4. **Scales and Metering Systems.** Provide weights and charts for checking the accuracy of the belt scales and the bituminous metering system. The scales and meters shall be accurate within a tolerance of 0.5%.

   The belt scale that weighs the combined aggregate shall be in accordance with the National Institute of Standards and Technology Handbook 44.

5. **Sampling Devices.** Use an approved method for sampling individual cold feeds and sequential sampling of aggregate and asphalt under full scale production. The sampling device and procedures used shall be approved by the Engineer and shall not interrupt normal operation.

6. **Platform Scales.** Make certified platform scales available for checking the asphalt metering system and for weighing or checking loads of asphalt mix as specified in **109**.

7. **Silos or Surge Bins.** Provide surge bins or storage silos as specified in **407.04.A.11**. If a silo is not provided, use an approved surge bin capable of holding sufficient mix to allow the plant to operate at an efficient rate of production, and ensure the system is capable of conveying, retaining, and delivering the bituminous mixture so that it is within the JMF and without segregation. The Engineer will reject mix that is damaged in any way.

   The surge bin may include an approved weighing system. If a weighing system is included in the surge system, provide approved weights for checking the weighing system. Check the system in maximum increments of 5,000 pounds and in a minimum of 3 increments. Check the system through its entire weighing range to or above the maximum weight that is expected to be applied. The system shall be accurate within a tolerance of 0.5%.

   For surge bins that do not include a weighing system, mount platform truck scales meeting the requirements of **109** under the loading hopper.

8. **Aggregate Feed.** Proportion aggregate by feeding each size aggregate from a separate cold bin. The belt that delivers the aggregate shall have a load cell capable of registering the amount of flow from each individual bin on a readout in the control office;

alternatively, the Contractor may proportion the aggregate by a linear system based on measured RPM of each feeder belt at a constant gate opening to feed aggregate at a predetermined rate that is set in the control office and that has a readout in the control office. Ensure that the rate of feed as determined from the bin settings agrees with the load cell on the collection belt feeding the dryer within a tolerance of ±10%. If the predetermined tolerance is exceeded, an alarm shall sound, and if corrections are not made within 60 seconds, the plant shall automatically shut down. The aggregate feed system shall employ computer controlled adjustments to automatically produce mix of the correct proportions over the plant's entire range of production rates.

If the Engineer has previously calibrated and approved the plant for temporary manual operation, the plant may run for a period not to exceed 2 working days, or portions thereof, on manual should a computer breakdown occur.

9. **Electronic Data Retention.** The computer system and automatic weighing system shall include means to retain all electronic data during electrical power failures.

407.05 Hauling Equipment

Trucks used for hauling bituminous mixtures shall have tight, clean, smooth metal beds that have been thinly coated with a minimum amount of paraffin oil, hydrated-lime solution, or other approved material from the Department's QPL to prevent the mixture from adhering to the beds. Immediately after loading at the plant, cover each truck with a cover of canvas or other suitable material that is of sufficient size to protect the mixture from the weather. Allow the cover to lap down along the sides and rear of the truck bed a minimum of 6 inches, and use tie downs to secure the cover at a maximum of 5-foot spacing along the sides and rear of the truck bed. When necessary to ensure the mixture will be delivered on the road at the specified temperature, insulate truck beds and securely fasten the covers. Provide a 3/8-inch hole in the side of each truck bed for inserting a thermometer.

407.06 Bituminous Pavers and Material Transfer Devices

A. Pavers

Bituminous pavers shall be self-contained, power-propelled units provided with an activated screed, equipped to be heated, and capable of spreading and finishing courses of bituminous plant mix material in lane widths applicable to the specified typical section and thickness shown on the Plans. All paver extensions shall be full assembly extensions, including activated and heated screeds, auger extensions, auger guards, and throw-back blades to place mix beneath the auger gearbox. When augers are extended, the maximum distance from the augers to the end plate shall be 18 inches. Augers shall be within 4 feet of the end plate on trailing edge extendible screeds; however, if using bolt-on extensions, extend the augers a distance equal to the length of the bolt-on extensions. Do not use strike-off boxes, except on sections of continuously varying width. For shoulders less than 8 feet in width and similar construction, the Contractor may place materials using approved mechanical spreading equipment.

Equip the paver with a receiving hopper that has sufficient capacity for a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed.

The screed or strike-off assembly shall produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

Equip all asphalt paving machines with automatic grade and slope controls. Both the grade and slope controls shall be in working order at all times; however, if the automatic controls fail, the Contractor may finish the day's work using manual controls, but shall not resume work the following day until both the grade and slope controls are in first class working order.

The Engineer may allow the Contractor to pave the inside shoulder concurrently with the inside traffic lane, subject to the Engineer's approval of the price adjustment for the mix used on the shoulder and of the paving and rolling equipment. In addition, the paver shall have an articulated screed that can be adjusted to fit the pavement cross-section and a power unit capable of handling the increased loading without undue stress.

B. Material Transfer Devices (MTDs)

Provide a Material Transfer Device (MTD) capable of transferring the asphalt from the truck or trailer to the asphalt paver without coming in contact with the asphalt paver. Use a MTD when placing all asphalt mixes, including shoulder mixes, with the exception that it will not be required when placing CS mix. An exception may be allowed due to lane width or safety issues if approved by the Engineer.

The MTD shall have a minimum storage capacity of 15 tons, and shall be equipped with mixing augers in the bottom of the storage hopper that are capable of remixing or re-blending the material as the material is removed from the storage hopper. The mixing augers shall be operational and used at all times during placement of the asphalt mixes. The MTD shall have a rear discharge conveyor that swivels a minimum of 150 degrees to allow feeding the paving machine from the front, side or rear.

Insert a stationary surge hopper into the paving hopper of the paver being fed by the MTD. The stationary surge hopper shall be considered as part of the MTD and shall have sloping sides (minimum of 60 degrees from horizontal) and a minimum storage capacity of 15 tons.

Obtain the Department's approval of models and manufacturers of MTDs before using on the Project. The Department will make no direct payment for use of an MTD and will consider all cost of furnishing and operating the MTD as incidental to the work.

407.07 Rollers

Provide self-propelled rollers, of steel-wheel, pneumatic tire, and/or vibratory type, which are in good condition and capable of reversing without backlash. Operate rollers at speeds slow enough to avoid displacement of the bituminous mixture. Equip rollers with a device for moistening and cleaning the wheels as required.

The required rollers shall be on the job, inspected, and approved before the start of paving operations.

Rollers shall meet the following additional requirements:

1. The steel-wheel roller shall weigh a minimum of 8 tons and may be either a three wheel or tandem type.

2. The pneumatic tire rollers shall have a minimum contact pressure of 85 pounds per square inch. The roller shall contain two axles upon which at least seven pneumatic-tire wheels are mounted so as to ensure the rear set of tires will not track the front set. The axles shall be mounted in a rigid frame provided with a loading platform or body suitable for ballast loading. Uniformly inflate the tires. Provide the Engineer with charts or tabulations of the contact area and contact pressures for the full range of tire inflation pressures and loadings for each size of roller tire provided. In place of a pneumatic tire roller, the Contractor may substitute a combination roller (pneumatic and steel wheel combination) of the make and model approved by the Department.

3. The Contractor may use vibratory rollers if the Engineer approves the particular roller proposed for use.

When paving the inside shoulder concurrently with the inside traffic lane, provide an additional roller, having a minimum width of 4 feet to a maximum width of 1 foot wider than the inside shoulder being paved, to compact the shoulder. Do not allow either the roller(s) on the inside traffic lane or the roller on the shoulder to traverse between the inside shoulder and the inside traffic lane.

407.08 Small Tools

Provide all necessary small tools, and keep them clean and free from accumulations of bituminous materials.

CONSTRUCTION REQUIREMENTS

407.09 Weather Limitations

The Contractor may place bituminous plant mix on properly constructed and accepted subgrade or previously applied layers if:

1. The subgrade and the surface upon which the bituminous plant mix is to be placed is free of excessive moisture, and

2. The bituminous plant mix is placed according to the temperature limitations specified in Table 407.09-1 and when weather conditions otherwise allow the pavement to be properly placed, compacted, and finished.

Table 407.09-1: Temperature Limitations

Compacted Thickness	Minimum Air or Surface Temperature (°F)	
	Unmodified mixes (PG 64, 67)	Modified mixes (PG 70, 76, 82)
≤ 1.5 inches	45	55
> 1.5 inches to < 3.0 inches	40	50
≥ 3.0 inches	35	45

3. Do not place bituminous plant mix, with a compacted thickness of 1.5 inches or less, between November 30 and April 1. Do not place bituminous plant mix, with a compacted thickness greater than 1.5 inches, between December 15 and March 16. Only place 411-TL, 411-TLD, and 411-OGFC mixtures when the pavement surface temperature and the ambient air temperature are a minimum of 55 °F and rising; limit placement to the period from April 1 to November 1.

4. The Contractor may request a variance from the above required temperature and seasonal limitations to pave at lower temperatures if there is a benefit to the public. Submit such requests in writing at least one week before the anticipated need, and include a Paving and Compaction Plan for Cold Weather that meets the Department's Procedure. The plan shall identify what practices and precautions the Contractor intends to use to ensure the mixture is placed and compacted to meet the specifications. The plan shall include compaction cooling curves estimating the time available for compaction, the intended production, haul, and compaction rates, with paver and roller speeds estimated. The Contractor may consider using such practices as the addition of rollers, reduced production and paving rates, insulated truck beds, and heating the existing surface.

If the specified densities are not obtained, stop all paving operations and develop a new plan. All mixture failing to meet specifications will be subject to price adjustments or removal and replacement at no cost to the Department.

407.10 Conditioning the Existing Surface

If bituminous mixes are to be placed upon an existing concrete pavement, with or without a bituminous overlay, remove all excess bituminous material from joints and cracks. Remove sections of existing pavement that are broken and pumping under traffic. Remove pavement where blowups have occurred at joints or cracks to provide a minimum opening of 1 foot for the full width of the pavement.

If the bituminous mixture is to be placed upon an existing bituminous pavement, remove areas containing excess bitumen and failures in the existing surface and base as directed by the Engineer.

Adjust all manholes and catch basin frames, which are associated with the storm sewer system, to the finished grades of the pavement. Unless otherwise specified, make such adjustments at no additional cost to the Department. The respective Utility Owner(s) will properly adjust all utility manholes, utility valve covers, and similar structures, to the finished grades of the pavement, unless otherwise shown on the Plans.

Remove unsatisfactory subgrade material encountered when removing the existing pavement and replace with approved material. Use overlay mixture or other approved material to fill openings left by the pavement and base removal to the full depth of the existing pavement, as directed by the Engineer, and compact the material in layers not to exceed 3 inches in thickness.

Paint contact surfaces of curbing, gutters, manholes, and other structures with a thin, uniform coating of bituminous material before placing the mixture against them.

When shown on the Plans, bring existing surfaces that are warped and irregular to uniform grade and cross-section using the leveling mixture specified in **307**.

407.11 Preparing the Bituminous Material

A. Hot Mix Asphalt (HMA)

Heat the bituminous materials for hot mixes to the required mixing temperature specified in Table 407.11-1.

Table 407.11-1: Mixing Temperatures

PG Binder Grade	Minimum Temperature (°F)	Maximum Temperature (°F)
PG 64-22, PG 67-22	270	310
PG 70-22	290	330
PG 76-22	290	330
PG82-22	290	330

The temperature for Grading AS, Grading ACRL, and Grading TPB mixtures shall be between 225 and 275 °F, except when modified binders are used, and then the temperatures shall be between 250 and 310 °F. Aggregate should be coated and no visible drain down should occur in storage silos or hauling equipment.

B. Warm Mix Asphalt (WMA)

The Contractor may subject the produced mixture to reduced production and placement temperatures by adding a chemical warm mix additive meeting **921.06.B.3** or by making plant modifications as specified in **407.04.A.12.**

When using either WMA technology, the maximum mixing temperature for any grade of asphalt cement shall be no more than 300 °F. At the beginning of a day's production, the producer may produce up to five truckloads at the temperatures specified in Table 407.11-1 to pre-heat placement equipment (pavers, transfer devices) before producing WMA. Indicate the laboratory mixing and compaction temperatures on the JMF during the mix design approval process. A tolerance of ±5.0 °F for each temperature will be allowed.

During test strip construction, ensure that all plant-produced WMA exhibits the ability to meet the test requirements for tensile strength ratio (TSR), conditioned tensile strength, Marshall Stability and flow,

volumetrics, and boil test, as specified for HMA in specifications **307**, **407**, and **411**. Procedures for testing shall be in accordance with that which is defined for quality control and acceptance in **407.03.D.2.h** and **407.20.B.3**, respectively.

407.12 Preparation of Aggregates

Unless otherwise specified, dry and heat the aggregate for hot mixes so as to produce a completed mix of a uniform temperature as specified in Table 407.11-1. Adjust flames used for drying and heating to avoid damage to the aggregate and to avoid soot on the aggregate.

On all plants requiring screens, screen the hot dried aggregate into two or more fractions as specified. Convey the separated fractions into separate compartments ready for batching and mixing with bituminous material.

407.13 Mixing

Combine the dried aggregates within the mixer in the amount of each fraction of aggregates required to meet the JMF. Measure the bituminous material and introduce it into the mixer in the amount specified by the JMF.

After introducing the required amounts of aggregate and bituminous material into the mixer, mix the materials as long as necessary to obtain a complete and uniform coating of the particles and a thorough distribution of the bituminous material. The Engineer will determine wet-mixing time for each plant and for each type of aggregate used, but in no case shall the wet-mixing time be less than 25 seconds for batch type plants and 40 seconds for continuous mix plants.

The temperature of the completed mixture (determined at the time it is dumped from the mixer), made with aggregates containing absorbed moisture that causes foaming or boiling in the completed mix, shall be not less than 225 °F. The temperature of the mix when it is discharged from the mixer shall not deviate from that specified in **407.11.A**.

The Contractor may place hot-mixed bituminous mixtures in surge or storage silos if the mixture as used from the silos meets all the specification requirements for the particular mix involved.

When using surge or storage silos, as approved by the Engineer, meet the following additional requirements:

1. Provide a surge bin or storage silo system meeting **407.04.A.11**.

2. Empty the storage silos or surge bins when directed by the Engineer to check material quantities.

3. Limit hours of plant operation, whether for storage or direct shipment to the road, to reasonable working hours to allow normal inspection of plant operations.

4. Remove bituminous mixtures placed in a surge bin on the same day in which it is stored.

5. The Contractor may store bituminous mixtures of Gradings A, AS, ACRL, and B for up to 48 hours, and Gradings BM, BM2, C, CS, CW, D, E, and F for up to 96 hours, in a storage silo by complying with the following:

   (a) Add an approved silicone additive to the asphalt cement for mixes to be stored beyond the day of mixing.

   (b) Keep the stored bituminous mixture sealed at all times during storage.

   (c) Fill the storage silo to at least 90% of capacity.

6. The Inspector will take samples of the stored material following the period of storage.

7. The stored material is subject to the same temperature, segregation, and laying requirements as required for unstored plant production.

8. The Engineer will reject mixtures having excessive segregation, lumpiness, or stiffness.

9. Locate the surge bins and storage silos in a position that enables the top of the truckload to be visible to the load operator during the loading operation.

407.14 Spreading and Finishing

For Contracts requiring night work, supply sufficient lighting and equipment as specified in **712.04.H**.

The temperature of the mixture at the time of depositing in the paver hopper shall be as specified in Table **407.11-1**.

Place the mixture upon an approved surface, and spread and strike-off to the established line, grade, and elevation using approved asphalt paving machine(s). The Engineer may approve use of echelon or full-width paving if plant production is capable of supplying the paver so that a constant forward speed can be maintained. Use preset control string lines to control the alignment of the outside edge of the pavement. Where multi-course pavements are placed, offset the longitudinal joint in one layer from that in preceding layer by approximately 1 foot; however, construct the joint in the top layer at the center-line of the pavement if the roadway comprises two lane widths, or at lane lines if the roadway is more than two lanes in width. Pave in the direction of traffic.

Do not feed a paving machine from more than one asphalt plant. Coordinate plant production and paving operations to ensure constant forward movement of the pavers. The Engineer will consider repetitive interruptions or stopping of the paver as cause for stopping the work until the Contractor corrects the situation. If the paver must be stopped for a significant period of time, construct a joint and move the paver from the roadway before the bituminous mixture has cooled sufficiently to prevent proper compaction. If the bituminous mixture cools to the extent that the required density cannot be obtained, remove and replace the mixture at no cost to the Department.

Unevenness of texture, segregation (including end-of-load segregation) as measured by a properly calibrated nuclear gauge, or tearing or shoving of bituminous mixture during the paving operation, shall be reason to stop the paving. Only resume paving operations when the condition is corrected. Immediately remove unacceptable mix and replace at no cost to the Department. The Department will not allow excessive throwing back of the bituminous mixture.

Provide automatic screed controls using either the string line, ski type grade reference system, or a non-contact averaging system on all work regardless of the paver width. The Engineer may require a string line reference system on new construction. If the base has been finished with equipment having automatic grade control or the Contractor demonstrates that an alternate method of spreading and finishing will result in a satisfactory riding surface, the Engineer may conditionally waive the string line requirement and authorize use of the ski type reference system. Regardless, the Engineer may at any time require the use of a string line reference system,

even if previously waived, if in the Engineer's opinion, the use of the string line will result in a superior riding surface. When the string line system is required on a multi-course pavement, use it on at least two courses exclusive of the surface course. When using the ski type system, the ski shall have the maximum practical length and in no case shall it be less than 40 feet in length. Pavement lanes previously placed with automatic controls or to form grade may serve as the longitudinal control reference for placing adjacent lanes by using a ski or joint matching shoe.

The string line reference system shall consist of suitable wire or twine supported by approved devices that are compatible with the type of automatic paver control system used. The string line and supports shall be capable of maintaining the line and grade shown on the Plans at the point of support while withstanding the tensioning necessary to prevent sag in excess of 1/4 inches between supports spaced 50 feet apart. Install additional supports to provide a minimum spacing of 25 feet, or less as directed by the Engineer, to remove the apparent deviation of the string line from theoretical grade.

Provide all materials, equipment, labor, and incidentals necessary to construct the string line reference system, and maintain the system until its use is no longer required. Include the cost of erecting and maintaining the string line reference system in the unit price bid for other items of construction. Have the string line reference system be complete in place at least 300 feet in advance of the point where the pavement is being placed. Automatic screed controls are not required on sections of projects where service connections and other conditions interfere with their efficient operation.

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impracticable, take the mixture from the hopper of the spreading machine and distribute it immediately into place using suitable shovels and other tools, and spread the mixture with rakes and lutes in a uniformly loose layer of such depth as will result in a completed course having the required thickness.

The Contractor and the Department will each be required to have an individual onsite that is certified by the Department through the HMA Roadway Certification Course.

407.15 Compaction

A. General

After spreading and striking-off the bituminous mixture and adjusting surface irregularities, thoroughly compact the mixture using methods approved by the Engineer and that are capable of achieving the specified density while the material is in a workable condition. When no density requirements are specified, use a system of compaction for roadway pavements that has previously produced the required bituminous pavement densities. The Engineer may require a control strip and random density samples to evaluate the system.

In general, accomplish compaction using a combination of the equipment specified in **407.07**. As a minimum, meet the following roller requirements, but increase the number of rollers if the required results are not being obtained.

1. Except as noted below, each paving train shall consist of a minimum of three rollers meeting **407.07**. The intermediate roller in each train shall be a pneumatic type. If the surface course contains a latex or polymer additive, the Contractor may use a steel wheel type roller for intermediate rolling instead of a pneumatic type provided the surface course meets density requirements.

2. Provide a minimum of two rollers when placing 307 CS, 411 TL, or 411 TLD mixtures. Perform breakdown rolling, as soon as possible and while the mixture is sufficiently hot, using a pneumatic tire roller having a minimum contact pressure of 85 pounds per square inch. Do not substitute a combination roller for a pneumatic roller when placing CS mix. Regulate the paver speed so rollers can maintain proper compaction of the mixture as determined by the Engineer.

3. With the Engineer's approval, the Contractor may reduce the minimum number of rollers listed above to one roller of either the steel-wheel or vibratory type on the following types of construction and projects:

    a. Shoulder construction,

b. Incidental construction such as bridge approaches and driveways, and

c. Projects containing less than 10,000 square yards of bituminous pavement.

4. Compaction of 411-OGFC mixtures shall consist of a minimum of two passes with a steel double drum asphalt roller with minimum weight of 10 tons, before the material temperature has fallen below 185 °F. Provide a minimum of two roller units so as to accomplish the compaction promptly following the placement of the material. At no time shall a pneumatic tire roller be used or a steel wheel roller be used in vibratory mode. If the roller begins to break the aggregate, immediately stop rolling.

Unless otherwise directed by the Engineer, begin rolling at the low side and proceed longitudinally parallel to the road centerline. When paving in echelon or abutting a previously placed lane, roll the longitudinal joint first, followed by the regular rolling procedure. When paving in echelon, rollers shall not compact within 6 inches of an edge where an adjacent lane is to be placed. Operate rollers at a slow uniform speed with the drive wheels nearer the paver, and keep the rollers as nearly as possible in continuous operation. Continue rolling until all roller marks are eliminated. Do not park rollers on the bituminous pavement.

To prevent adhesion of the mixture to the rollers, keep the wheels properly moistened with water or water mixed with very small quantities of detergent or other approved material. Limit excess use of liquid.

Do not refuel rollers on bituminous pavements.

Along forms, curbs, headers, walls and other places not accessible to the rollers, compact the mixture thoroughly using hot hand tampers, smoothing irons, or with mechanical tampers. On depressed areas, the Contractor may use a trench roller to compact the mix.

B. Density Requirements

Meet the applicable density requirements specified in Tables 407.15-1 to 407.15-4.

Table 407.15-1: Density Requirements for ADT 1,000 or less

Mix Type	% of Maximum Theoretical Density (Average)	No Single Test Less Than, %
A	90	87
B, BM & BM2	90	87
C & CW	90	87
D	90	87
E	90	87

Table 407.15-2: Density Requirements for ADT 1,000 to 3,000

Mix Type	% of Maximum Theoretical Density (Average)	No Single Test Less Than, %
A	91	89
B, BM & BM2	91	89
C & CW	91	89
D	91	89
E	91	89

Table 407.15-3: Density Requirements for ADT 3,000 or greater

Mix Type	% of Maximum Theoretical Density (Average)	No Single Test Less Than, %
A	92	90
B, BM & BM2	92	90
C & CW	92	90
D	92	90
E	92	90

Table 407.15-4: Density Requirements for any ADT

Mix Type	% of Maximum Theoretical Density (Average)	No Single Test Less Than, %
Shoulder Mix (B, BM, BM2, D or E)	88	85
AS and A-CRL	None [1]	None
CS	None [1]	None
TL, TLD, and OGFC	None	None

[1] The Department will waive density requirements on Bituminous Plant Mix Base Grading ACRL, Grading AS and Bituminous Plant Mix Leveling Course, Grading CS; however, the Contractor shall use a system of compaction for roadway pavements that has been approved by the Engineer. When placing Bituminous Plant Mix Base Grading ACRL and Grading AS, the Contractor may replace the specified intermediate roller (pneumatic tire) with a steel-wheel type if irreparable damage to the pavement is occurring.

Correct base or surface course that tests below the minimum density so that the density of the area is equal to or above the minimum, at which point it can be used to determine the average density of the lot. Do not place any successive layers until the area has been corrected. As necessary to determine the classification of open graded or dense graded mixes and to measure segregation, use AASHTO T 269 or ASTM D3203.

Repair or replace defective mixture to the satisfaction of the Engineer and at no cost to the Department.

The Department will perform density testing in accordance with **407.20.B.5**.

C. Test Strips

Construct test strips for all A, B, BM, BM2, C, CW, D, and E mixes to establish rolling patterns, to calibrate nuclear gauges, to verify that the base course or surface course meets the density requirements of the specifications, and for mix design and production verification as required.

Before constructing the test strip, obtain the Engineer's approval of the underlying base or other pavement course. Compact the test strip using equipment as specified in this subsection and **407.07**.

Construct the test strip at the beginning of work on the pavement course. Prepare new test strips when:

1. A change in the JMF is necessary;

2. A change in the source of materials occurs;

3. A change in the material from the same source is observed;

4. There is reason to believe that the test strip density is not representative of the bituminous mixture being placed; and when

5. A change in paving or compaction equipment occurs.

With the approval of the Engineer, the Contractor may construct additional test strips.

Construct each test strip with approved bituminous mixture. The test strip shall remain in place as a section of the completed work. Construct each test strip to be 1 paver width wide, with an area of at least 400 square yards and of the depth specified for the pavement course concerned.

Immediately after placing the bituminous mixture, begin compacting the test strip. Perform compaction in a continuous and uniform manner over the entire test strip.

Continue compacting the test strip until additional roller coverage will produce no appreciable increase in density (1 pound per cubic foot), as measured using a nuclear gauge. Use the roller coverage necessary to obtain this maximum density as the rolling pattern for the remainder of the project.

Take cores on the test strip at ten randomly selected locations as designated by the Engineer. Do not take cores within 2 feet of the longitudinal edges for calibration. Provide these cores to the Department for use in calibrating the nuclear gauge and to verify that

the average density of the test strip meets the density requirements of the specifications. The Department will report all densities using the corrected nuclear gauge readings. Correction factors are specific to the nuclear gauges used during the test strip construction. If a different nuclear gauge needs to be used for acceptance, it will be necessary to cut new cores from the ongoing pavement construction to calibrate the new gauge.

When testing test strip cores, the Department will determine density (bulk specific gravity) in accordance with AASHTO T 166, Method A only. All core samples shall be completely dry before testing. Air drying is permitted provided core samples are weighed at 2-hour intervals until dry in accordance with AASHTO T166, Section 6.1. Cores may also be dried in accordance with ASTM D7227.

If the density of the asphaltic concrete in the test strip does not meet specification requirements, make whatever changes are necessary to obtain the specified density. Use other sources and combinations of aggregates as necessary, subject to the Engineer's approval, to produce a mix meeting the required density.

407.16 Joints

Place bituminous paving as continuously as possible. Do not pass rollers over the unprotected end of a freshly laid mixture unless approved by the Engineer. Form transverse joints by cutting back on the previous run to expose the full depth of the course. Use a brush or sprayed coat of bituminous material on contact surfaces of longitudinal and transverse joints just before placing additional mixture against the previously rolled material.

407.17 Pavement Samples

When directed, cut samples from the compacted pavement for testing by the Engineer. Take samples of the mixture for the full depth of the course at locations selected by the Engineer. Cut the samples with a power saw or core drill. Samples shall have a top surface area of at least 10 inches.

Fill holes left by taking samples with the same type mixture that was used to construct the course sampled, and compact to conform to the surrounding pavement. Cut samples and repair sample holes at no cost to the Department.

407.18 Surface Requirements

Test the surface with a 12-foot straightedge applied parallel to the centerline of the pavement. The deviation of the surface from the testing edge of the straightedge shall not exceed that specified for the respective types of bituminous construction under the applicable Subsections of these Specifications.

Test the transverse slopes of tilted pavements with a string-line and string-level applied at right angles to the centerline of the pavement. The percent of slope, when computed for the full width of the pavement, shall not deviate more than 0.5 percentage points from that shown on the Plans.

Test the crown in crowned pavements with a string-line applied at right angles to the centerline of the pavement. The crown shall not deviate more than 1/2 inch from that shown on the Plans.

Correct deviations that exceed the specified tolerances. Remove and replace pavement that cannot be corrected to comply with the specified tolerances at no cost to the Department.

COMPENSATION

407.19 Method of Measurement

The Department will measure:

1. Asphalt cement and mineral aggregate, including mineral filler when required, by the ton and as follows:

    a. If the mix is loaded from a storage or surge bin, the Department will determine quantities by weighing the completed mix on truck scales meeting **109** and calculating the weight of asphalt cement and mineral aggregate based on the percentages measured into the mix by the appropriate scales or meters as specified in **407.04**.

    b. If the mix is loaded directly into the hauling equipment from a batch plant, the Department will measure asphalt cement and mineral aggregate in batch quantities by scales or scales and meters as specified in **407.04.B.**

c. If a continuous mix plant is used, the Department will measure Bituminous Material for Bituminous Plant Mix Pavement by the ton in accordance with **109**. The Department will determine quantities of mineral aggregate, including mineral filler when required, by weighing the bituminous pavement mixture on truck scales meeting **109**, and deducting the weight of the bituminous material from the weight of total mixture accepted.

d. If recycled mix is permitted, the Department will measure the completed mix, including new mineral aggregate, planings, asphalt cement, and additive, by the ton in accordance with **109**.

2. Removal and disposal of existing surface (concrete) by the square yards in accordance with **109,** if such work is required as specified in **407.10**. Such measurement will include the removal of bituminous overlay.

3. Removal and Disposal of Existing Surface (Bituminous) by the square yards in accordance with **109**. Such measurement shall include the removal of base material, except concrete, as directed by the Engineer.

4. Removal of unsatisfactory subgrade material where existing pavement has been removed by the cubic yard, in accordance with **203.09**. The Department will measure material used to replace such undercutting in accordance with the specification for the type of material used.

5. Adjustment of catch basin grates and frames, water valve boxes, gas valve boxes and manhole covers and frames by each when required.

6. Liquid anti-strip additive by the gallon.

7. Hydrated lime by the ton.

The Department will measure bituminous mixtures used to fill openings left by pavement removal as specified in this Subsection **407.19**. The Department will measure base materials used to fill openings left by base removal as provided for in the respective Sections for each type specified.

The Department will not measure chemical additives or modifiers, when required, for payment, but will consider them incidental to asphalt cement.

The Department will not measure mineral filler separately for payment, but will consider it incidental to mineral aggregates.

407.20 Basis of Payment

A. General

The Department will pay for accepted quantities of Asphaltic Concrete (Hot Mix) with or without recycled material, at the contract prices, complete in place, as follows:

Item	*Pay Unit*
Bituminous Plant Mix Base (Hot Mix)	Ton
Aggregate	Ton
Asphalt Cement	Ton

The Department will pay for liquid anti-strip additive and hydrated lime anti-strip additive based on certified invoices of material cost not to exceed $15 per gallon and $90 per ton, respectively. This payment is full compensation for all labor, materials, equipment, and other incidentals incurred in using the anti-strip additive.

The Department will pay for accepted quantities of Prime Coat or Tack Coat as specified in **402** or **403**, respectively.

The Department will pay for the work required to prepare the subgrade, sub-base, base, or surface in accordance with **307.06** and **411.06** as provided for in the applicable Section or Subsection under which the work is performed.

The Department will not make direct payment for polymer or latex additives, but will consider such additives to be included in the price bid for the modified asphalt cement or modified mixture.

B. Acceptance of the Mixture

1. **General.** The Department will perform all necessary sampling and testing for acceptance purposes in strict conformance with the Department's Policies in addition to monitoring and observing the

Contractor's quality control test procedures and results. However, the Engineer will reject for use in the work any load or loads of mixture which, in the Engineer's opinion, are unacceptable due to excessive segregation, improper coating of aggregates, or excessively high or low temperature.

The Engineer will accept bituminous mixture at the plant with respect to gradation and asphalt content, on a lot basis. A standard size lot at the asphalt plant will consist of a day's production. The number of sublots in a lot will vary from n=1 to n=4 according to Table 407.20-1.

Table 407.20-1: Sublot Requirements

Quantity (tons)	Number of Sublots
3001 – 4000	4 tests
2001 – 3000	3 tests
1001 – 2000	2 tests
Less than 1000	1 test

When the total plan quantity of any mix is less than 500 tons, the Department will accept the mix on the basis of visual inspection and Contractor Quality Control certification. The Department may run extraction, gradation analysis, or other tests deemed necessary for acceptance purposes.

2. Defective Materials

a. Acceptance or Rejection. Consider the Engineer's decision to be final as to the acceptance, rejection, or acceptance at an adjusted payment of the lots.

It is the intent of these specifications that each lot of material will meet specification requirements at the time of acceptance testing. The Department will not take check samples for acceptance purposes.

All acceptance samples will be split, and half of the sample will be retained by the Inspector. If the results of an acceptance test are questioned, the Central Laboratory will test the remaining half of the acceptance sample. The Department

will use the results obtained by the Central Laboratory to evaluate the quality of the lot.

b. Disposition of Lots. Remove and replace, at no cost to the Department, nonconforming lots of materials, products, or complete construction that cannot be corrected by reworking. Alternatively, the Department may accept the nonconforming work at an adjusted payment as specified in these Specifications or as directed by the Engineer.

When a deficiency is determined, the Department will apply the applicable payment as specified in these Specifications to the entire lot. When multiple deficiencies occur, the Department will apply the applicable partial payments to the lot of material that is identified by each deficiency. The Department will apply the payment adjustment for each deficiency separately so as not to affect any other payment adjustment occurring for the same lot; however, if there are two or more deficiencies in the gradation acceptance tests, the Department will apply only the greater payment adjustment. When an area or linear measurement is used to specify lot size, the Department will determine the equivalent tons of mix placed in each lot by using the average calculated spread from the plant inspector's daily report for that day's production.

3. Acceptance. The Engineer will base acceptance of the mixture on test results of consecutive random samples taken from each lot. One random sample will be taken from each sublot. The bituminous mixture will be sampled at the plant according to AASHTO T 168. The percent bitumen content of the mixture will be determined according to AASHTO T 164 or by AASHTO T 308 except as herein revised.

The Contractor may use an approved ignition furnace instead of a vacuum extractor for the use in determining asphalt content and gradation. The method of calibration and test procedures shall comply with AASHTO T 308 Method A and the following.

At least once per week, per mixture, during production, check the AASHTO T 308 correction factors with a sample of the aggregate mixture proportions, blended at the optimum asphalt content. Adjust the correction factor accordingly. Keep records of all correction factors for all mixtures. Adjusted payment for asphalt

content and gradation will be based on the ignition furnace results as specified in Table 407.20-2. Use of this alternative equipment shall be at no additional cost to the Department.

The percents passing the sieves will be determined in accordance with AASHTO T 30.

Table 407.20-2: Acceptance Schedule of Payment (Asphalt Plant Mix Characteristics)

Characteristics	Pay Factor	Average Arithmetic Deviation of the Lot Acceptance Test from the JMF	
		1 Test	2 Tests or more
Asphalt Cement Content [1] (Extraction or ignition oven)	1.00	0.00-0.30	0.00-0.25
	0.95	0.31-0.35	0.26-0.30
	0.90	0.36-0.40	0.31-0.35
	0.80 [2]	over 0.40	over 0.35
Gradation 3/8 inch sieve and larger	1.00	0.00-6.50	0.00-5.70
	0.95	6.51-7.08	5.71-6.20
	0.90	7.09-7.66	6.21-6.69
	0.80 [2]	over 7.66	over 6.69
Gradation No. 4 sieve [3]	1.00	0.00-4.62	0.00-4.00
	(0.95	4.63-5.20	4.01-4.50
	0.90	5.21-5.77	4.51-5.00
	0.80 [2]	over 5.77	over 5.00

Characteristics	Pay Factor	Average Arithmetic Deviation of the Lot Acceptance Test from the JMF	
		1 Test	2 Tests or more
Gradation No. 8, 16, 30 & 50 sieves [3]	1.00	0.00-3.80	0.00-3.30
	0.95	3.81-4.46	3.31-3.91
	0.90	4.47-5.12	3.92-4.52
	0.80 [2]	over 5.12	over 4.52
Gradation No. 100 & 200 sieves [3]	1.00	0.00-1.80	0.00-1.60
	0.95	1.81-2.00	1.61-1.75
	0.90	2.01-2.20	1.76-1.90
	0.80 [2]	over 2.20	over 1.90

[1] Does not apply to 307 Grading A, AS, or ACRL mixes.

[2] If approved by the Engineer, the Contractor may accept the indicated partial pay. The Department may require removal and replacement at no cost. The Contractor may remove and replace at no cost to the Department at any time.

[3] When there is more than one reduced payment relating to gradation in 1 lot of material, only the greatest reduction in payment will be applied. Reductions applicable for any other reason will be cumulative.

Deduction for both asphalt content and gradation deficiencies will be cumulative. The Department will apply deductions to the total price of the mix (asphalt cement and aggregate combined) under the item for Asphalt Cement Content and Gradation Deduction.

4. **Additional Tests.** The Engineer may perform any test at any time to determine the effectiveness of the Contractor's quality control. In addition, the Department will conduct production verification tests parallel to that which is defined for quality control in **407.03.D.2.h**.

5. **Acceptance for Mix Density on the Roadway.** The Department will apply a deduction in payment, not as a penalty but as liquidated damages, for failure to meet the density requirements specified in **407.15**. As soon as practicable after the final rolling is completed on each lot, the Department will perform 5 density tests at locations determined by the Engineer, and will compute an average of all such tests. Deductions for failure to meet density requirements will be computed to the nearest 0.1% as a percentage

of the total payment otherwise due for each lot. The percent of total payment to be deducted will be 5 times the percent the average in-place density for each lot that fails to meet **407.15**. The Department will make deductions in monies due the Contractor for failure to meet the density requirements under the item for Density Deduction. The Department will conduct acceptance testing for density in accordance with ASTM D2950 unless otherwise specified. The Department inspector will be a certified Asphalt Roadway Technician.

For density testing purposes, the Department will divide the pavement into lots of 10,000 square yards, except for 307 Gradings A, B, BM, and BM2, which will be divided into lots of approximately 5,000 square yards. Five density tests will be performed in each lot and the average results compared with the requirements specified in Tables **407.15-1** to **407.15-4**. At the beginning of a project or at any time it is deemed advisable, the Department may consider smaller lots to evaluate compaction methods or for other reasons as approved or directed by the Engineer.

The Department will randomly select acceptance test samples that are representative of the lot or sublot. Although performing compaction after the acceptance test is acceptable, the Department will use the original test result to determine lot density. The Department may take information only samples to spot check compaction, but will not use these tests for acceptance testing.

C. Adjustments

1. Asphalt Cement Adjustment. If the Engineer sets an asphalt content other than that specified in Tables **307.09-1** and **411.09-1**, the Department will calculate a price adjustment, based on the asphalt content set by the Engineer and the Monthly Bituminous Index for the specific grade asphalt on the mix design, according to the following formula:

$$PA = \frac{MBI \times (DA - BA) \times T}{100}$$

Where:

PA = Price Adjustment

MBI	=	Monthly Bituminous Index
DA	=	Percent asphalt set on the mix design
BA	=	Percent asphalt specified above to be used for bidding
T	=	Total tons asphalt mix for price adjustment

2. Specific Gravity. In cases where the effective combined specific gravity of the mineral aggregate exceeds 2.80, the Department will adjust the tonnage of mineral aggregate, or plant produced mixture, for payment by multiplying the tonnage of mineral aggregate, or plant produced mixture, used by a specific gravity of 2.80 and dividing by the higher specific gravity.

3. Loss on Ignition (LOI). If the approved JMF includes a surface mixture of limestone with gravel, granite, slag, quartzite or gneiss, perform tests for the percent LOI of the limestone aggregate in the asphalt paving mix as specified in **407.03.E.3**.

If the percent of LOI in the aggregate differs by more than ±2% from the LOI indicated in the JMF, the Department will make a payment deduction in the price bid for the mix, not as a penalty but as liquidated damages. The percent of total payment to be deducted will be 5 times the percent that the LOI exceeds the JMF tolerance of ±2%.

Replace or overlay all mix produced with aggregate tested and found to have a LOI that differs more than ±6% from the LOI indicated in the JMF at no additional cost to the Department.

To determine the deduction, the Department will use lots of approximately 5,000 square yards. The Department inspector will perform sampling and testing to establish the LOI according to the Department's sampling and testing procedures. If the initial tests indicate a variation in the LOI of greater than ±2% than the value shown on the mix design, the Contractor shall perform the additional sampling necessary to establish the LOI of the aggregate in each lot, with the cost of the sampling being included in the contract unit prices bid for the paving items.

The Department will make deductions for excess variation in LOI under the item for Material Variation (Deduction).

SECTION 410 – BITUMINOUS PLANT MIX SURFACE COURSE (COLD MIX)

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DESCRIPTION

410.01 Description

This work consists of constructing a Bituminous Plant-Mix Surface Course (Cold Mix), composed of aggregate and bituminous material, on a designated base in one or more layers and at the rate of application shown on the Plans or established by the Engineer.

MATERIALS

410.02 Materials

Provide materials as specified in:

Mineral Aggregate **903.10**
Emulsified Asphalt, Grade AE-3 ..... **904.03**

The Engineer will accept mineral aggregate for gradation in the stockpile at the paving plant site, and plant mixed material after being spread on the road. The Engineer may conditionally accept bituminous material at the source.

410.03 Composition of Mixtures

Combine the specified mineral aggregate and bituminous material in such proportions as to produce mixtures within the master composition limits specified in Table 410.03-1.

Table 410.03-1: Proportions of Total Mixture, Percent by Weight

Material Components	Percent by Weight
Mineral Aggregate	93.0 - 95.0%
Emulsified Asphalt	5.0 - 7.0%

EQUIPMENT

410.04 Equipment

Provide equipment as specified in **407.04** with the following modifications:

1. Automatic screed control devices will not be required on the bituminous pavers.

2. Plant equipment required for heating or drying materials and for blending different size aggregates will not be required.

CONSTRUCTION REQUIREMENTS

410.05 Limitations

Comply with the limitations specified in **407.09**.

410.06 Preparing Designated Surface

Prepare the designated surface upon which the material is to be placed as specified in **404.05**.

410.07 Mixing

Perform mixing as specified in **407.13**. The Contractor may either stockpile the mix or haul it directly from the mixer to the road. If stockpiled, ensure that the material shows no damage from weather or signs of stripping during handling.

410.08 Spreading and Finishing

Perform spreading and finishing and spreading choker aggregate as specified in **407.14**.

410.09 Compaction

Perform compaction operations as specified in **407.15**.

410.10 Surface Requirements

Comply with the surface and testing requirements specified in **407.18** to ensure that the deviation of the surface from the testing edge of the straightedge does not exceed 1/4 inch.

410.11 Maintenance

Perform maintenance as specified in **404.09**.

COMPENSATION

410.12 Method of Measurement

The Department will measure Mineral Aggregate and Emulsified Asphalt for Bituminous Plant Mix Surface Course (Cold Mix) in accordance with **407.19**.

410.13 Basis of Payment

The Department will pay for accepted quantities of Bituminous Plant Mix Surface Course (Cold Mix) at the contract prices, complete in place, as follows:

Item	*Pay Unit*
Emulsified Asphalt	Ton

Mineral Aggregate (Including Choker) Ton

The Department will measure and pay for the work required to prepare the designated surface, as provided for under **410.06**, in accordance with the applicable Section or Subsection under which the work is performed.

SECTION 411 – ASPHALTIC CONCRETE SURFACE (HOT MIX)

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DESCRIPTION

411.01 Description

This work consists of constructing an asphaltic concrete pavement, composed of a mixture of coarse aggregate, fine aggregate, mineral filler if specified or required, and asphalt cement, on a prepared roadbed at the rate of application shown on the Plans or established by the Engineer.

The provisions of **407** shall apply to this work unless otherwise stipulated.

MATERIALS

411.02 Materials

Provide materials as specified in:

Mineral Aggregate **903.11**
Mineral Filler **903.16**
Asphalt Cement, PG 64-22, 70-22, 76-22 or 82-22 ..... **904.01**
Chemical Additive **921.06.B**

The Engineer will accept mineral aggregate, bituminous material, and plant mix in accordance with **407.02**.

411.03 Composition of Mixtures

A. General

Composition of mixtures shall be as specified in **407.03**.

B. Proportioning

Combine the specified mineral aggregate and asphalt cement according to the proportions specified in Table 411.03-1.

Table 411.03-1: Proportions of Total Mixture, Percent by Weight

Surface Course	Effective Combined Mineral Aggregate	Asphalt Cement
Grading D	93.0 - 94.3	5.7 - 7.0 (1)
Grading E (2)	93.0 - 94.3	5.7 - 7.0 (1)
Grading E (shoulders)	92.0 - 94.7	6.0 - 6.5 (1)
Grading TL	92.5 - 94.3	5.7 - 7.5 (1)
Grading TLD	93.0 - 94.3	5.7 - 7.0 (1)
Grading OGFC	92.0 - 94.0	6.0 - 8.0 (1)

(1) If the effective combined specific gravity of the aggregate exceeds 2.80, the above proportions may be adjusted as directed by the Engineer. The upper limit for flow values shall not apply to mixes with modified asphalt liquids.

(2) The minimum allowable asphalt cement content for 411E low volume mixtures is 5.3%.

1. **Grading D.** In addition to the other requirements of these Specifications, the composition of the mineral aggregate shall be such that when combined with the required amount of bitumen, the resultant mixture will meet Table 411.03-2.

Table 411.03-2: Mixture Properties (All Roads)

Mix[1]	Stability, Min. lb-ft [2]	Flow 0.01 inch [3]	Design Void Content % [2]	Production Void Content % [2]	VMA, Min. % [2]	Dust-Asphalt Ratio [4]
411D	2,000	8 – 16	4.0 ± 0.2	3 - 5.5	14	0.6 - 1.2

(1) In order to identify critical mixes and make appropriate adjustments, the mix design shall have these required production properties for the bitumen content range of Optimum Asphalt Cement ±0.25%.

(2) Tested in accordance with AASHTO T 245 with 75 blows of the hammer on each side of the test specimen, using a Marshall Mechanical Compactor.

(3) Flow will only be required when using a non-modified binder (PG 64-22 or 67-22).

(4) The dust to asphalt ratio is the percent of the total aggregate sample that passes the No. 200 sieve, as determined by AASHTO T 11, divided by the percent asphalt in the total mix.

2. Grading E. In addition to the other requirements of these Specifications, if using Grading E for the riding surface, the composition of the mineral aggregate shall be such that, when combined with the required amount of bitumen, the resultant mixture will meet Table 411.03-3.

Table 411.03-3: Mixture Properties (High vs. Low Volume Roads)

Mix	Traffic Volume	Stability Minimum lb-ft [1, 3]	Flow 0.01 inch [2]	Design Void Content % [1]	Production Void Content % [1]	VMA, Min % [1]
411E	High Volume (ADT > 1,000)	2,000	8 - 16	4.0 ± 0.2	3 - 5.5	14
411E	Low Volume (ADT ≤ 1,000)	1,500	8 - 16	3.5 ± 0.5	2 - 5	n/a

[1] Tested according to AASHTO T 245 with 75 blows of the hammer on each side of the test specimen, using a Marshall Mechanical Compactor.

[2] Flow will only be required when using a non-modified binder (PG 64-22 or 67-22)

[3] Minimum stability for shoulder mixes will be 1,500 lb-ft and optimum asphalt cement content for shoulder mixes shall be as directed by the Regional Materials Supervisor.

If the design criteria specified above cannot be obtained with the aggregate submitted to the laboratory for design, provide another source of aggregate.

3. Gradings TL and TLD. In addition to the other requirements of these specifications, the composition of the mineral aggregate shall be such that, when combined with the required amount of bitumen, the resultant mixture will meet Table 411.03-4.

Table 411.03-4: Mixture Properties (Gradings TL and TLD)

Mix	Stability, Min lb-ft [1]	Design Void Content % [1]	Production Void Content % [1]	Minimum VMA % [1]	Dust-Asphalt Ratio [2]
411TL	2,000	4.0 ± 0.2	3 - 5.5	16	1.0 - 2.0
411TLD	2,000	3.8 ± 0.3	3 - 5.5	14	0.6 - 1.2

[1] Tested according to AASHTO T 245 with 75 blows of the hammer on each side of the test specimen, using a Marshall Mechanical Compactor.

[2] The dust to asphalt ratio is the percent of the total aggregate sample that passes the No. 200 sieve, as determined by AASHTO T 11, divided by the percent asphalt in the total mix.

4. Grading OGFC. In addition to the other requirements of these specifications, the composition of the mineral aggregate shall be such that, when combined with the required amount of bitumen, the resultant mixture will meet Table 411.03-5.

Table 411.03-5: Mixture Properties (Grading OGFC)

Mix	Minimum Void Content %	Voids in Coarse Aggregate % [1]	Max. Cantabro Abrasion Loss (Non-Aged) % [1]	Drain Down Loss % [2]
411OGFC	20	$VCA_{DRC} > VCA_{MIX}$	20	<0.3%

[1] As described in National Asphalt Pavement Association (NAPA) Publication IS-115, "Design, Construction and Maintenance of Open-Graded Friction Courses"

[2] Tested in accordance with AASHTO T 305.

C. Recycled Asphalt Pavement and Recycled Asphalt Shingles

1. Recycled Asphalt Pavement. The Contractor may use asphalt pavement that has been removed from a Department project or other State Highway Agency project by an approved method and stored in a Department approved stockpile. RAP combined with the appropriate aggregate, asphalt cement, and anti-strip additive

when required shall produce a mixture that will otherwise meet all the requirements specified in **903.11** and this Section **411**. The Contractor may use RAP in each mix specified in Table 411.03-6.

Table 411.03-6: Use of Recycled Asphalt Pavement

Mix Type	% RAP (Non-processed) (1)	Maximum % RAP (Processed) (2)	Maximum % RAP Processed and Fractionated (3)	Maximum Particle Size (inch)
411D (PG64-22, PG67-22)	0	15	20	1/2
411D (PG70-22, PG76-22, PG82-22)	0	10	15	1/2
411E (Roadway)	0	15	20	1/2
411E (Shoulder)	15	30	35	1/2
411TL (PG64-22, PG67-22)	0	15	15	5/16
411TL (PG70-22, PG76-22, PG82-22)	0	10	10	5/16
411TLD (PG64-22, PG67-22)	0	15	15	5/16
411TLD (PG70-22, PG76-22, PG82-22)	0	10	10	5/16

(1) "Non-processed" refers to RAP that has not been crushed and screened or otherwise sized such that the maximum recycled material particle size is less than that listed above prior to entering the dryer drum.

(2) "Processed" refers to RAP that has been crushed and screened or otherwise sized such that the maximum recycled material particle size is less than that

Mix Type	% RAP (Non-processed) (1)	Maximum % RAP (Processed) (2)	Maximum % RAP Processed and Fractionated (3)	Maximum Particle Size (inch)

above prior to entering the dryer drum.

(3) "Fractionated" refers to RAP that has been processed over more than one screen, producing sources of various maximum particle sizes (e.g., 3/4 to 1/2 inch, 1/2 inch to #4, etc.). The Contractor may use the larger percentages of fractionated RAP specified only if individual fractions of two different maximum particle size are introduced into the plant as separate material sources for increased control.

All mixes shall contain at least 80% virgin asphalt, except for 411E Shoulder Mix which shall have at least 65% virgin asphalt.

Obtain a representative sample from the recycled material stockpile and establish a gradation and asphalt cement content as required. Determine the gradation and asphalt content of the recycled material at the beginning of a project and every 2,000 tons thereafter. The stockpile asphalt cement content for all recycled material shall not vary from the JMF by more than ± 0.8%. Table 411.03-7 specifies the stockpile gradation tolerance for all recycled material on each sieve.

Table 411.03-7: Stockpile Gradation Tolerances for Recycled Material

Size	Tolerance
3/8 inch sieve and larger	± 10%
No. 4 sieve	± 8%
No. 8 sieve	± 6%
No. 30 sieve	± 5%
No. 200 sieve	± 4%

The Contractor is responsible for its own sampling and testing of the RAP as well as new materials for bid purposes, and for submitting the JMF as specified in **407.03**. After mixing, the moisture content of the total mix shall be no more than 0.1% as

determined by oven drying, and the provisions for lowering the temperature because of boiling or foaming shall not apply.

The Engineer will accept mixture for aggregate gradation and asphalt content based on extractions in accordance with AASHTO T 164 or in accordance with AASHTO T 308.

2. Recycled Asphalt Shingles (RAS). Recycled Asphalt Shingles (RAS) may be included to a maximum of 5% of the total weight of mixture. The percentage of RAS used will be considered part of the maximum allowable RAP percentage. The ratio of added new asphalt binder to total asphalt binder shall be 80% or greater for all 411 mixes. Either the mix producer or the RAS supplier shall obtain a representative sample from the recycled material stockpile and establish a gradation and asphalt cement content as required. Determine shingle asphalt binder content according to AASHTO T 164 Method A, with a minimum sample size of 500 grams. Determine the gradation and asphalt content of the recycled material at the beginning of the Project and every 2,000 tons of recycled material used thereafter. The stockpile asphalt cement content for all recycled material shall not vary by more than 0.8%. All RAS material shall be processed to a minimum 100% passing the 3/8 inch sieve and a minimum 90% passing the No. 4 sieve.

To conduct the gradation testing, air dry a 500 to 700-gram sample of processed shingle material, dry sieve over the 3/8-inch and No. 4 sieves, and weigh. For mix design purposes, the Contractor may use the aggregate gradation specified in Table 411.03-8 as a standard gradation instead of determining the shingle gradation according to AASHTO T 30.

Table 411.03-8: Standard Gradation (for Mix Design Purposes)

Sieve Size	Total Percent Passing
3/8 inch	100
No. 4	97
No. 8	95
No. 16	80
No. 30	60
No. 50	50
No. 100	40
No. 200	30

An aggregate bulk specific gravity (G_{sb}) of 2.650 may be used instead of determining the shingle aggregate G_{sb} according to AASHTO T 84. In addition, the effective binder available for mixing with additional aggregates shall be considered as 75% of the total binder content as determined by AASHTO T 164 and shall be the value listed as the RAS binder content on the JMF.

Scrap asphalt shingle shall not contain extraneous waste materials. Extraneous materials including, but not limited to, asbestos, metals, glass, rubber, nails, soil, brick, tars, paper, wood, and plastics, shall not exceed 0.5% by weight as determined on material retained on the No. 4 sieve. To conduct deleterious material testing, take a representative 500 to 700-gram sample of processed shingle material, place over the No. 4 sieve, and pick and weigh all extraneous waste material retained on the No. 4 sieve. Base the percent of extraneous material on the total sample weight.

RAS shall contain less than the maximum percentage of asbestos fibers based on testing procedures established by the Department, or State or Federal environmental regulatory agencies. Analyze a minimum of one sample of processed asphalt roofing material for every 500 tons of material processed for the presence of asbestos.

Before a JMF for a particular design is approved, submit the following, along with the materials and information specified in **407.03**:

a. Certification by the processor of the shingle scrap describing the shingle scrap content and source.

b. A 1000-gram sample of the processed RAS material for inspection (new designs only).

Stockpile RAS separately from other salvage material. Do not blend RAS material in a stockpile with other salvage material. Do not blend Manufacture Waste Scrap Shingles (MWSS) and Tear-Off Scrap Shingles (TOSS). In addition, do not blend virgin sand material with the processed shingles, to minimize agglomeration of the shingle material.

All RAS supplied to a Department project shall come from a certified shingle processor/supplier approved by the Division of Materials and Tests.

D. Anti-Strip Additive

Check asphaltic concrete surface mixtures (Grading D and E) for stripping by the Ten Minute Boil test for dosage rate and ASTM D4867 (Root-Tunnecliff procedure) for moisture susceptibility.

If moisture susceptibility is indicated, then mix an approved anti-strip agent with the asphalt cement at the dosage recommended by the respective test and as specified in **921.06.B**.

EQUIPMENT

411.04 Equipment

Provide equipment as specified in **407.04** through **407.08**.

To construct shoulder mixes with recycled material, provide equipment that complies with **407**, except modify the asphalt plant as approved by the Engineer to accommodate the addition of asphalt planings. If using a batch plant to produce recycled mix, heat the aggregate to a temperature that will transfer sufficient heat to the cold planings to produce a mix of uniform temperature within the specified range.

CONSTRUCTION REQUIREMENTS

411.05 General Requirements

Construct the pavement as specified in **407.09**, **407.11**, **407.12**, and **407.14** through **407.17** and the following Subsections.

411.06 Preparing the Designated Surface

Prepare the designated surface upon which the material is to be placed as specified in **404.05.**

Ensure that loops used for traffic signals are installed before applying the final surface.

411.07 Mixing

Perform mixing as specified in **407.13**. In addition, the mixing cycle for surface course mixtures may require a dry-mixing period.

411.08 Surface Requirements

The surface shall meet the requirements specified in **407.18**, and when tested according to the provisions of that Subsection, the deviation of the surface from the testing edge of the straightedge shall not exceed 1/4 inch.

COMPENSATION

411.09 Method of Measurement

The Department will measure Mineral Aggregate, including Mineral Filler when required, Asphalt Cement for Asphaltic Concrete Surface (Hot Mix), and other related items in accordance with **407.19**.

For bidding purposes, use the asphalt cement content specified in Table 411.09-1.

Table 411.09-1: Asphalt Cement Content

Mix Type	Asphalt Content, %
411-D	5.9
411-E Roadway	6.3
411-E Shoulder	6.3
411-TL	6.3
411-TLD	5.9
411-OGFC	6.0

If the Engineer sets an asphalt content other than that specified above, the Department will make a price adjustment based on the asphalt content set by the Engineer and the Monthly Bituminous Index for the specific grade asphalt cement on the mix design. The Department will calculate a price adjustment in accordance with **407.20**.

411.10 Basis of Payment

The Department will pay for accepted quantities of Asphaltic Concrete Surface (Hot Mix) or asphaltic Concrete Surface (Hot Mix) (Shoulders) with or without recycled material, at the contract prices, complete in place, in accordance with **407.20**.

SECTION 414 – EMULSIFIED ASPHALT SLURRY SEAL AND MICRO-SURFACING

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DESCRIPTION

414.01 Description

This work consists of the design, testing, construction, and quality control required to apply an emulsified asphalt slurry seal surface (slurry seal) or micro-surface.

The slurry seal or micro-surface shall consist of a mixture of an approved emulsified asphalt, mineral aggregate, water, and specified additives or modifiers, properly proportioned, mixed, and uniformly spread over a prepared surface. The cured slurry or micro-surface shall have a homogeneous appearance, and adhere firmly to the surface.

MATERIALS

414.02 Materials

Provide materials as specified in:

Mineral Filler (Portland Cement)..... **901.01**
Mineral Aggregate (Slurry Seal)..... **903.12.A**
Mineral Aggregate (Micro-Surface) **903.12.B**
Emulsified Asphalt **904.03**
Water **921.01**

For a slurry seal, use a Type CQS-1h emulsified asphalt. For micro-surfacing, use a Type CQS-1hp emulsified asphalt.

414.03 Composition of Mixture

At least 2 weeks before beginning work, submit a signed original of a mix design, performed by a qualified laboratory and covering the specific materials to be used on the Project, to the Materials and Tests Division for acceptance, together with representative samples of each ingredient to be used in the mixture. Identify the samples with information related to sources, type of materials, and project number.

Once the materials are approved, make no substitutions without first testing and obtaining the approval of the laboratory that prepared the mix design. Do not begin work until the Materials and Tests Division has evaluated and accepted the mix design.

Provide a laboratory report showing the results of tests performed on individual materials and comparing their values to those required by this specification. Use job aggregates in all laboratory design tests. Mixing tests shall pass at the maximum expected air temperature in ISSA T113.

A. Slurry Seal

1. Testing. The laboratory report shall provide the information specified in Table 414.03-1 for the slurry seal mixture.

Table 414.03-1: Quick-Set Emulsified Asphalt Slurry Seal

Test	Requirement
Mixing Time Test, seconds at 77 °F (TB-113)	120 min
Mix Time, at 50 and 100 °F	(informational)
Set Time Tests:	
30-Minutes-Blotter Test (TB-102)	no brown stain
Displacement Test	no displacement
Water Resistance Test, at 30 minutes (TB-102)	no discoloration
Wet Stripping Test, % coating (TB-114)	90% min
System Compatibility (TB-115)	Pass
Set Time Tests: 30 minutes (TB-139)	12 kg-cm min
Early Rolling Traffic Time: 2 hours (TB-139)	20 kg-cm min
Wet Track Abrasion Test, loss in g/ft2 (TB-100)	75 max, 6-day soak

For roadways having greater than 1,500 ADT, in addition to the tests specified in Table 414.03-1, the mixture shall also meet the requirements specified in Table 414.03-2 for the ISSA T109, Test Method for Measurement of Excess Asphalt in Bituminous Mixtures by Use of a Loaded Wheel Tester and Sand Adhesion.

Table 414.03-2: Excess Asphalt (for Roadways with > 1,500 ADT)

Roadway ADT	Requirement
1,500 – 3,000	Maximum: 55 grams/psf sand adhesion, 1,000 cycles @ 125 lbs
3,000+	Maximum: 50 grams/psf sand adhesion, 1,000 cycles @ 125 lbs

2. Composition. Emulsified asphalt slurry seal shall consist of a uniform mixture of aggregate, emulsified asphalt, latex solids when shown on the Plans, mineral filler, and water. The emulsified asphalt manufacturer shall certify the compatibility of all ingredients (including the mix set additive) of the mix.

The percent of residual asphalt based on the weight of the dry aggregate shall be between 7.5 and 13.5%, with a mixture control tolerance of ±0.50%.

Ensure that the aggregate gradation and percent residual asphalt, as provided in the slurry seal design accepted by the Engineer, is maintained within the mixture control tolerances stated herein.

The Contractor may add Portland cement to obtain the desired dispersion and working characteristics of the slurry provided that the addition of Portland cement is stated on the slurry seal design, does not exceed 3% of the weight of the aggregate, and has a mixture control tolerance of ±0.25%.

Portland cement added for dispersion of the slurry seal shall be a commercial quality, non-air entraining cement and shall not be considered as mineral filler for the purpose of satisfying the gradation requirements of the aggregate.

Pre-wet the aggregate with a minimum amount of water before blending with the emulsified asphalt to obtain a fluid, homogeneous slurry mixture of the proper consistency. Do not add to the mix any additional water above that quantity required by the slurry seal mix design to obtain a more workable mixture.

B. Micro-Surfacing

1. Testing. The laboratory report shall provide the information specified in Table 414.03-3 for the micro-surface mixture.

Table 414.03-3: Micro-Surfacing

Test	Requirement
Mixing Time Test, seconds at 77 °F (T-102)	120 min
Mix Time, at 50 and 100 °F	(informational)
Set Time Tests: 30 minutes (T-139)	12 kg-cm min
Early Rolling Traffic Time: 60 minutes (T-139)	20 kg-cm min
Wet Stripping Test, % coating (T-114)	90% min
Wet Track Abrasion Test, loss in g/ft^2 (T-100)	75 max 6 days 50 max 1 hour
Measurement of Excess Asphalt (T-109)	50 $grams/ft^2$ max
	Sand Adhesion, 1,000 Cycles at 125 lbs
Classification Compatibility (T-144)	11 pt. min
Loss on Ignition (LOI) Test, TDOT Spec. **407.03.E.3**	(informational)

2. Composition. For the paving mixture, the design shall verify the functioning of the set regulating additives and shall present certified test results for the Engineer's approval. Aggregate in the mixture shall be representative of material to be used on the Project.

Obtain the Engineer's approval of the design before using. Proportions for the design shall be within the limits specified in Table 414.03-4.

Table 414.03-4: Micro-Surface Mixture Design Requirements

Material	Requirement
Modified Emulsified Asphalt Residue by Dry Weight of Aggregates	5.0-9.0%
Mineral Additive by Dry Weight of Aggregate	0.5%-3.0%
Latex or Polymer Based Modifier	3% minimum and as required to provide the specified properties
Mix Set Additive	As required to provide the specified properties
Water	As required to produce consistency

The Contractor may add Portland cement to obtain the desired dispersion and working characteristics of the mix, provided that the addition of Portland cement is stated on the micro-surface design, does not exceed 3% of the weight of the aggregate, and has a mixture control tolerance of ±0.25%.

Portland cement added for dispersion shall be a commercial quality, non-air entraining cement and shall not be considered as mineral filler for the purpose of satisfying the gradation requirements of the aggregate.

Proportion the mixture so as to achieve the test strip requirements specified in **414.06**.

C. Applicable Specifications

Consider the specifications and test methods identified in Table 414.03-5 to be part of this specification.

Table 414.03-5: Applicable Specifications

Title	Source
Mixing, Setting and Water Resistance Test to Identify "Quick-Set" Emulsified Asphalts	ISSA TB-102

Title	Source
Wet Track Abrasion of Micro Seals	ISSA TB-100
Measurement of Micro-Seal Consistency	ISSA TB-106
Test Method for Measurement of Excess Asphalt in Bituminous Mixtures by Use of a Loaded Wheel Tester	ISSA TB-109
Outline Guide Design Procedure for Slurry Seal	ISSA TB-111
Method to Estimate Micro-Seal Spread Rates and to Measure Pavement Macrotexture	ISSA TB-112
Trial Mix Procedure for Slurry -Seal Design	ISSA TB-113
Wet Stripping Test for Cured Slurry-Seal Mixes	ISSA TB-114
Test Method to Classify Emulsified Asphalt/Aggregate Mixture Systems by Modified Cohesion Tester. Measurement of Set and Cure Characteristics	ISSA TB-139
Classification Compatibility	ISSA TB-144
Design, Testing and Construction of Micro-Seal	ASTM D3910
Quantitative Extraction of Bitumen for Bituminous Paving Mixtures	ASTM D2172

The blended asphalt mixture, when combined with aggregate and mineral filler, shall have the following characteristics:

1. Be capable of filling up to 1/2-inch wheel ruts in one pass.
2. Be capable of field regulation of the setting time.
3. Be suitable for nighttime placement.

EQUIPMENT

414.04 Equipment

Maintain all equipment, tools, and machines used to perform this work in satisfactory working condition. Have available at all times a device capable of determining aggregate moisture within 3 minutes.

Immediately after loading, cover all trucks with a cover of canvas or other suitable material. Allow the cover to lap down along the sides and rear of the truck bed a minimum of 6 inches, and secure with tie downs at a maximum of 5-foot spacing along the sides and rear of the truck bed. Before starting hauling operations, ensure that all trucks are equipped to meet these requirements.

Provide power brooms, power blowers, air compressors, water flushing equipment, and hand brooms capable of thoroughly cleaning all cracks and the old surface. Provide hand squeegees, hand brooms, shovels, and other incidental equipment as necessary to perform work.

A. Mixing Equipment

The mixing equipment shall be re-supplied with all materials while depositing the mixture on the roadway so as to provide a continuous, non-stop surfacing operation. Produce the paving mixture in a self-propelled, front feed, continuous loading, mixing machine equipped with a positive, non-slipping aggregate delivery system and an interconnected, positive displacement water-jacketed gear pump to accurately proportion ingredients.

Equip the mixing machine with an approved fines feeder that has an accurate metering device or method to introduce a predetermined amount of mineral filler into the mixer at the same time and location as the mineral aggregate. Provide a spray bar to completely wet the aggregate dropping down to the pug mill with additive and water. The twin-shafted multi-blade pug mill shall be a continuous flow type and a minimum of 50 inches long. Introduce the emulsion above the third point of the mixer to ensure proper premixing 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.

Perform mixing in a manner that does not cause premature breaking of the emulsified asphalt. The mixing unit of the mixing chamber shall be capable of thoroughly blending all ingredients.

Equip the mixer with a remote forward speed control at the back mixing platform so the back operator can control forward speed and level of mixture in paving or rut box.

Provide a computerized material monitoring system with integrated material control devices that are readily accessible and positioned so the amount of each material used can be determined at any time. Provide a back-up electronic materials counter that is capable of recording running count totals for each material being monitored. Equip the mixer with a radar ground measuring device. Calibrate each material control device before each mix application and as often thereafter as the Engineer deems necessary. The computer system shall have the capability to record, display and print the following information:

1. Individual sensor counts for emulsion, aggregate, cement, water, and additive
2. Aggregate, emulsion, and cement output in pounds per minute
3. Ground travel distance
4. Spread rate in pounds per square yard
5. Percentages of emulsion, cement, water, and additive
6. Cumulative totals of aggregate, emulsion, cement, water, and additive
7. Scale factor for all materials

Ensure the computer system is functional at the beginning of work and during each calibration.

Equip the mixing machine with a water pressure system and fog type spray bar, adequate for complete fogging of the surface ahead of the spreading equipment.

The mixing machine shall include controls for proportioning and calibrating the aggregate feed. The aggregate feed device shall have a revolution counter, so that the amount of aggregate used may be determined at any time, and a positive locking feed gate.

Provide an emulsion pump of the positive displacement type and equipped with a device that can be used to determine the amount of

emulsion used at any time. Arrange the emulsion pump, meter, and piping to allow calibration of the meter by weighing a metered volume. The pump shall deliver the emulsion to the mixer box at a uniform rate, which shall not vary more than 2% from the required quantity.

Equip the water pump with a minimum of two valves. One valve shall establish the required water flow. The other valve shall be a quick acting valve to start and stop the water flow.

The mixing machine shall have sight gauges located at the material storage tanks for the asphalt emulsion and water.

Equip the mixing machine with approved metering devices that can be used for calibration purposes and for estimating the quantities of materials used during any one period. If the metering devices stop working properly, do not use the mixing machine until the necessary repairs have been made.

Provide satisfactory means to allow positive interlocking control between the flow of aggregate from the bins and the flow of emulsion from the pump. Calibrate each mixing unit in the Engineer's presence before starting construction. Document the individual calibration of each material at various settings, which can be related to the machine's metering devices. When calibrating the emulsion system, run a minimum of three tests, with each test run being a minimum of 40 gallons. To calibrate the aggregate delivery system, perform tests at three different gate settings, with two test runs at each gate setting and a minimum of 425 pounds per test run. To calibrate the filler (cement) delivery system, perform three tests at a minimum of 25 pounds per test. Use certified scales. Only use machines that have been calibrated and accepted by the Engineer to perform the work. The Engineer may require additional calibrations during the process of the work.

B. Spreading Equipment

Attach to the mixer a hydraulically adjustable (adjustable while applying mixture) type spreader box with a positive screed adjustment for yield control and a positive adjustment for the joint matcher. The box shall be equipped with the following: ribbon flights mounted on an adjustable shaft to continually agitate and distribute the materials throughout the box; curb bumpers and replaceable runners with a minimum of 5-foot long end runners; and a sufficient walkway to

provide access to either side of the spreader box without walking through the freshly laid material.

The spreader box shall be heavy duty with crossbracing for rigidity and a manufacturer's weight of not less than 1,400 pounds at a width of 12 feet. The box shall be capable of laying mix to a width of 14 feet. The equipment shall provide sufficient turbulence to prevent the mix from setting in the box or causing excessive side build-up or lumps. To prevent loss of mixture from the box, attach flexible seals, front and rear, in contact with the road.

Equip the full width application box with a secondary strike-off located approximately 2 to 3 feet behind the primary strike-off to minimize transverse corrugations. The secondary strike-off shall have elevation and width adjustments similar to the primary strike-off. It shall have a pivot point where it can be tilted for texturing or raised completely off the surface. Rut filling shall require a steel or high density strike-off on the spreading equipment, as approved by the Engineer, or the use of a rut box. Use a rut box for filling ruts in excess of 3/8 inches unless otherwise shown on the Plans.

Operate the spreading equipment so as to prevent the loss of mixture on super-elevated curves. Spread mixture to fill cracks and minor surface irregularities and achieve a uniform skid-resistant surface without causing skips, lumps, or tears in the finished mat.

For slurry seals, the use of burlap drags or other drags necessary to obtain the desired finish requires the Engineer's approval. Replace drags having excessive build-up. Keep drags in a completely flexible condition at all times. Do not use drags on micro-surfacing.

CONSTRUCTION REQUIREMENTS

414.05 Preparing the Existing Surface

Immediately before applying the tack coat and mixture, remove all dust, dirt, vegetation, and other deleterious material from the existing surface by brooming, washing with water under high pressure, blowing with compressed air, or other approved methods. Obtain the Engineer's approval of the cleaned surface before applying the tack coat and mixture. Remove all thermoplastic pavement markings flush with the existing surface before applying the tack coat.

Establish stations at 1,000-foot intervals on the entire project before placing materials. Clearly identify and maintain the stations until project completion.

414.06 Applying Slurry Seal and Micro-Surfacing

A. Application

Before placing the mixture, apply a tack coat of SS-1h, CQS-1h, or CQS-1hp emulsion with an asphalt distributor. The tack coat shall consist of one part emulsion and three parts water. The application rate shall be 0.10 to 0.15 gallons per square yard of the diluted emulsion. The Engineer will determine the actual application rate. Apply the tack coat as specified in **403.**

Apply the emulsified asphalt slurry seal at a rate of 16 ± 2 pounds per square yard based on dry aggregate weight unless otherwise shown on the Plans. Vary the rate of application within the range specified above as required by the condition of the pavement to obtain a minimum thickness of 1/8 inch above the high points of the milled areas and 1/4-inch thickness on unmilled areas.

Apply micro-surface as follows:

1. **Rut-fill Course.** If a rut-fill course is specified, apply enough material to fill the wheel paths without excess crowning (overfilling). An excess crown is defined as 1/8 inches after 24 hours of traffic compaction. Apply rut-fill courses in widths from 5 to 6 feet for each wheel path. Provide a smooth, neat seam where two rut-fill passes meet. Take care to restore the designed profile of the pavement cross-section. Feather the edges of the rut-fill course to minimize the use of excess material.

2. **Leveling Course.** If a leveling course is specified, apply at a rate of 14 ± 2 pounds per square yard based on dry aggregate.

3. **Surface Course.** If a surface course is specified and it is placed over a leveling course, apply at a rate of 18 ± 1 pounds per square yard based on dry aggregate. If a surface course is specified and it is not placed upon another micro-surfacing course, apply the paving mixture at a minimum rate of 22 pounds per square yard based on dry aggregate.

Apply micro-surface at the rates as shown on the Plans for leveling and surface courses.

Apply the mixture based on dry aggregate weight as shown on the Plans.

The maximum allowable speed of the machine shall be 130 feet per minute. The Engineer will determine the maximum allowable speed for rut filling. Place the final surface seal uniformly across the width of the traffic lane unless otherwise specified or directed. The action of the squeegee shall allow the mix to flow freely, leaving a smooth, uniformly textured surface.

Unless otherwise directed by the Engineer, pre-wet the surface with water by fogging ahead of the spreader box. Closely control pre-wetting to prevent water from accumulating to the point of running off or puddling.

As the aggregate and emulsion are being loaded into the aggregate/emulsion support trucks or mixing machine, perform a final screening of the aggregate by sieving it through screening equipment capable of removing random oversize material.

Ensure that the mixture is of the desired consistency when deposited on the surface. Add no additional elements to the mixture once placed. Ensure that a sufficient amount of mixture is carried in all parts of the spreader at all times to obtain complete coverage. Do not allow lumping, balling, or unmixed aggregate, or segregation of the emulsion and aggregate fines from the coarse aggregate. If the coarse aggregate settles to the bottom of the mix, remove the mix from the pavement. The mixture shall have proper consistency so as to avoid excessive splattering and excessive free water. Do not spray water into the spreader box during lay down operations. Use hand tools, lutes, and squeegees to spread mix on areas not accessible to the machine spreading equipment. After curing, perform rolling with a pneumatic-tired roller for sections of pavement not to be exposed to traffic. The roller shall be equipped with tires with a pressure of 40 to 60 pounds per square inch.

Demonstrate throughout the course of the Project that the number of trucking units being used is sufficient to ensure a continuous forward operation. Repeated stopping and starting of the machine will not be allowed.

B. Quality Control

Produce a mixture that complies with the mix design and the quality control tolerances. Apply the slurry seal or micro-surface at the rates shown on the Plans. Use the methods described in this section to measure compliance. Maintain all quality control documentation and make it available to the Engineer upon request or at the completion of the work.

1. Asphalt Content. Calculate the percent asphalt content of the mixture by randomly reading the equipment computer display a minimum of three times a day. The quality control tolerances from the mix design is ± 0.5%.

2. Application Rate. Calculate the yield of the course being placed by randomly reading the equipment computer display a minimum of three times a day. The quality control tolerance from the specified application rate is ±2 pounds per square yard.

3. Documentation. Maintain a daily report and a lot sheet as follows:

a. Daily Report. Include the following information on the daily report:

(1) Aggregate used, ton (dry)
(2) Slurry or micro-surfacing emulsion used, ton
(3) Bituminous materials for tack coat and for fog seal, ton
(4) Cement used, ton
(5) Water used in mixture, gallons
(6) Additive used in mixture, gallons

b. Lot Sheet. Divide the Project into lots of no more than 20,000 square yards. For each lot, maintain a lot sheet, providing the following information:

(1) Control Section, Job Number, Route, Engineer (Project Inspector)
(2) Date, Air Temperature
(3) Control Settings, Calibration Values, Unit Weight of Emulsion (pounds per gallon), Percent Residue in Emulsion

(4) Beginning and Ending Intervals
(5) Computer display readings for material usage (Beginning, Ending, and Total)
(6) Length, Width, Total Area (square yards), Pounds of Aggregate, Pounds of Emulsion, Pounds of Cement
(7) Percent of each Material, Percent of Asphalt Cement, Application Rate, Combined Application Rate (pounds per square yard)
(8) Mix Design (Percent Portland Cement, Percent Emulsion, Percent Asphalt Cement)
(9) Contractor's Authorized Signature
(10) Calibration Forms

4. **Test Strip Construction.** Prior to production application, place a 1,000 ± 50-foot test section. Place the test strip at the same time as paving is to take place, night or day, and under the same ambient conditions. Ensure the test strip is able to carry normal traffic within 60 minutes. If normal traffic cannot be carried, adjust the emulsion or mixture, and construct another test strip.

414.07 Joints

Prevent excessive build-up, uncovered areas, or unsightly appearance on longitudinal or transverse joints. Avoid excessive overlap on longitudinal joints. Provide spreading equipment of suitable width to produce a minimum number of longitudinal joints throughout the Project. When placing micro-surfacing, terminate the final center joint of the micro-surfacing at a point that will fall directly under the final permanent center line. Before opening to traffic, apply pavement markings meeting **716.06**. Allow a maximum of 3 inches for overlap of the longitudinal lane line joints. Also the joint shall have no more than 1/4-inch difference in elevation when measured with a 10-foot straightedge over the joint. Extend final edge lines a minimum of 4 inches over the old longitudinal edge joint. Ensure straight lines along curbs and shoulders. Do not allow runoff on these areas. Keep lines at intersections straight to provide a neat appearance.

414.08 Fog Seal Application

Meet **403.05**.

414.09 Weather Limitations

Only place micro-surface and slurry seal when the pavement surface temperature and the ambient air temperature are a minimum of 50 °F and rising. Do not apply micro-surface or slurry seal during foggy or rainy conditions. Limit placement to the period from April 1 to October 31.

414.10 Opening to Traffic

Micro-surface material shall cure sufficiently within 1 hour after application, and slurry seal material shall cure sufficiently within 2 hours after application, so that traffic can be allowed on the pavement without damaging the surface. Do not allow traffic on the mixture until it has cured sufficiently to prevent pickup by vehicle tires. Maintain traffic control as necessary to prevent damage to the mixture. Repair damage to the mixture caused by traffic at no cost to the Department.

COMPENSATION

414.11 Method of Measurement

The Department will measure:

1. Emulsified Asphalt Slurry Seal by the square yards complete in place and accepted.

2. Micro-Surfacing by:

    a. The square yards complete in place and accepted; or by

    b. The quantity in tons (dry) of aggregate, including mineral filler, and the quantity in tons of latex or polymer modified emulsion used in the accepted portion of the micro-surfacing, based on the calibrated metering device affixed to the micro-surface mixing machine.

3. Bituminous Materials for Tack Coat and for Fog Seal by the ton of undiluted emulsion.

The quantity for “Bituminous Material for Tack Coat”, Item No. 403.01, should be 1/4 of the estimated application rate. The Department will not

directly pay for latex or polymer additives when used and will consider their cost to be included in the price bid for the respective items.

For bidding purposes, assume the emulsified asphalt content for the slurry mix design is 15%. When Micro-Surfacing is bid by the square yard, assume the design asphalt content is 12%. If the Engineer sets an emulsified asphalt content for slurry seal other than that stated above, the Department will make a price adjustment based on the emulsified asphalt content set by the Engineer and the invoice price of the emulsified asphalt F.O.B. the project delivery point. The Department will calculate the price adjustment according to the following formula:

$$PA = \frac{[IP \times (DA - BA) \times T]}{100}$$

Where:

PA =	Price Adjustment
IP =	Invoice price of emulsified asphalt cement
DA =	Percent emulsified asphalt set on the mix design
BA =	Percent emulsified asphalt specified above to be used for bidding
T =	Total tons of aggregate for price adjustment as determined by the metering system on the mixing machine

The Department will make payment to the Contractor for additional emulsified asphalt as provided for above at the purchase price F.O.B. the project delivery point, as verified by invoice, with no compensation allowed for further handling or processing. The Department will be reimbursed from monies due the Contractor for a decrease in emulsified asphalt content in the amount equal to the purchase price F.O.B. the project delivery point.

414.12 Basis of Payment

The Department will pay for accepted quantities, determined in accordance with **414.11**, at the contract prices, complete in place, which payment shall be full compensation for all equipment, materials, labor and incidentals necessary to complete the work.

SECTION 415 – COLD PLANING OF BITUMINOUS PLANT MIX PAVEMENTS

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DESCRIPTION

415.01 Description

This work consists of cold planing an existing bituminous plant mix pavement.

EQUIPMENT

415.02 Equipment

Provide a power broom, a water truck, and a planing machine, as well as equipment to remove the material planed from the pavement.

The planing machine shall be a power operated, self-propelled milling machine or grinder capable of removing bituminous concrete to the required width, depth, profile, cross-slope, and surface texture. The machine shall be capable of accurately establishing profile by referencing from either the existing pavement or from an independent grade control and shall have positive means for controlling cross-slope. The machine shall have a floating moldboard with sufficient down pressure to plane the milled surface. The machine shall have an effective means of removing cuttings from the pavement and for preventing dust from escaping into the air.

When milling the Interstate or controlled access freeways, the planing machine shall be capable of restoring pavement profile with a non-contact

leveling system. The non-contact leveling system shall have a minimum of three sensors dispersed the length of the machine.

The maximum spacing between teeth on the cutter drum shall not exceed 5/8 inches. Provide supplemental equipment as necessary to remove material in areas that cannot be reached by the planing machine.

CONSTRUCTION REQUIREMENTS

415.03 General Requirements

Coordinate operations so that vertical longitudinal faces do not exceed 1-1/4 inches in height in areas to be used by public traffic. Taper transverse faces in a manner approved by the Engineer to avoid creating a traffic hazard. Perform cold planing in the direction of traffic.

When milling roadways for hot mix overlays, operate the planing machine at a consistent forward speed to provide an acceptable surface texture. The maximum allowable forward speed shall be 60 feet per minute when the teeth spacing is between 1/2 and 5/8 inches, and 80 feet per minute when the teeth spacing is less than 1/2 inch.

After planing, ensure that the finished surface provides a smooth riding surface free of scallops, scabs, gouges, ridges, oil film, and other imperfections of workmanship, has a uniform texture, and is true to the required grade and cross-section. The elevation of the longitudinal edges of adjacent cuts shall not differ more than 1/8 inch.

Do not begin milling unless the subsequent layer of pavement can be placed within the limitation specified in **407.09**.

Thoroughly sweep the planed pavement immediately behind the machine, and haul away all materials swept up. When the Engineer deems necessary, provide and use a water truck to control dust.

Where sound pavement has been gouged, torn, or otherwise damaged during the milling operations, or damage is done to any other property of any kind including utility frames, grates, and covers, make repairs at no cost to the Department. Take appropriate measures so that the cold planing operation does not trap water.

415.04 Surface Requirements

Where the planed pavement is not to be resurfaced, provide a uniform texture throughout the Project and a satisfactory riding surface. The average texture depth shall be no less than 0.20 inches.

The finished surface on the Interstate and controlled access freeways shall be of uniform profile throughout, without any scabbing, scallops, gouges, ridges, or other imperfections resulting from worn cutter teeth, improper operating speeds, poor equipment maintenance, or other instances of poor workmanship. The cross-slope shall be as shown on the Plans in the tangent, transition, and super-elevated curve sections.

The finished surface after the final cut shall not show a deviation greater than 1/8 inch from a 10-foot straightedge, and the cross-slope shall not deviate more than 3/8 inches in 10 feet. Correct all irregularities exceeding these limits.

Texture all approaches and tapers when required by the Engineer. Length, width, and depth of cut on approaches and tapers shall be as determined by the Engineer. Match the approaches and tapers to the finished cut on the main line, and transition to the existing surface to within ±1/8 inch.

When deemed necessary by the Engineer, transition private entrances to provide a smooth approach to the roadway.

Unless otherwise shown on the Plans, take ownership of the cuttings and remove them from the Project.

COMPENSATION

415.05 Method of Measurement

The Department will measure Cold Planing of Bituminous Pavement by the quantity of material removed in tons or cubic yards, or by the square yard of planed pavement. The method of measurement will depend upon the pay item designated in the proposal.

Where payment is by the square yard, the Department will measure the pavement acceptably planed by the square yard in accordance with **109.**

Unless otherwise specified, the Department will not measure water used to control dust for separate payment but will consider it incidental to the planing operation.

415.06 Basis of Payment

The Department will pay for the accepted quantity of Cold Planed Bituminous Pavement at the contract unit price, which payment shall be full compensation for all labor, materials, equipment, hauling, and incidentals necessary to plane the pavement, control dust, and dispose of the cuttings.

PART 5 – RIGID PAVEMENT

501 – PORTLAND CEMENT CONCRETE PAVEMENT 390

SECTION 501 – PORTLAND CEMENT CONCRETE PAVEMENT

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DESCRIPTION

501.01 Description

This work consists of constructing a pavement of Portland cement concrete, with or without reinforcement as specified, on a prepared surface.

MATERIALS

501.02 Materials

A. General

Provide materials as specified in:

Portland Cement [(1)]	**901.01**
Fine Aggregate [(2)]	**903.01**
Coarse Aggregate	**903.03**
Preformed Joint Fillers (Non-Extruding and Resilient Types)	**905.01**
Joint Sealants	**905.05**
Reinforcing Steel and Dowel Bars	**907**
Curing Materials	**913**
Water	**921.01**
Air-Entraining Admixtures	**921.06**
Chemical Additives [(3)]	**921.06**
Fly Ash	**921.15**
Ground Granulated Blast Furnace Slag	**921.16**

(1) Use Type I, Type IL, or Type IS unless otherwise specified or allowed. Use Type I or Type IL with either (1) fly ash or (2) ground granulated blast furnace slag or (3) both fly ash and ground granulated blast furnace slag as a partial cement replacement unless otherwise specified or allowed. When using Type I or Type IL cement with either (1) fly ash or (2) ground granulated blast furnace slag or (3) both fly ash and ground granulated blast furnace slag as a partial cement replacement, the requirements of **604.03** shall apply.

(2) Do not use sand manufactured from limestone or other polishing aggregates in the construction of traffic lanes.

(3) Only use chemical additives with the Engineer's approval. When additives are allowed, do not reduce the cement content of the concrete as designed without chemical additives.

B. Using Fly Ash and Ground Granulated Blast Furnace Slag as Partial Cement Replacement

Fly ash of different classes or sources used as a partial cement replacement in Portland cement concrete will not be allowed. Fly ash may only be used as a partial cement replacement in Type I and Type IL cement.

Ground granulated blast furnace slag of different grades or sources used as a partial cement replacement in Portland cement concrete will not be allowed. Ground granulated blast furnace slag may only be used as a partial cement replacement in Type 1 Portland cement.

The Contractor may use both fly ash and ground granulated blast furnace slag as a partial cement replacement on the same project. When Type IS cement is used on a project, do not use fly ash or ground granulated blast furnace slag as a partial cement replacement

1. **Fly Ash Submittals.** Do not begin producing Portland cement concrete with fly ash as a partial cement replacement until the concrete supplier provides the following information to the Engineer:

    a. Copies of the results of all tests performed by the fly ash producer within the previous 30 days on shipments to the concrete supplier. Results shall include:

        (1) Fineness (percent retained on No. 325 sieve)
        (2) Loss on Ignition (LOI)
        (3) Specific gravity
        (4) Soundness (autoclave expansion)
        (5) Moisture content
        (6) Pozzolanic activity, 7-day cement

    b. A notarized certification from the fly ash producer stating that the fly ash meets **921.15**.

2. **Ground Granulated Blast Furnace Slag Submittals.** Do not begin producing Portland cement concrete with ground granulated blast furnace slag as a partial cement replacement until the concrete supplier provides the following information to the Engineer:

a. Copies of the results of all tests performed by the ground granulated blast furnace slag producer within the previous 30 days on shipments to the concrete supplier. Results shall include:

(1) Fineness (percent retained on the No. 325 sieve.)
(2) Air content of slag mortar
(3) Individual sample slag activity index (percent)
(4) Average of last five consecutive samples, slag activity index (percent)
(5) Specific gravity
(6) Sulfide sulfur (S) (percent)
(7) Sulfate ion reported as SO_3 (percent)
(8) Total alkalis (Na_2O+0.658 K_2O)
(9) Compressive strength (28-day)

b. A notarized certification from the ground granulated blast furnace slag producer stating that the slag meets **921.16**.

501.03 Proportioning and Quality Assurance of Concrete

A. Proportioning

1. General. Submit the proposed concrete design to the Engineer for approval. Determine the design using saturated surface dry aggregate weights. Verify the design by preparing trial batches meeting the requirements of these specifications. Ensure that the concrete design is prepared by a Department certified Class 3 concrete plant technician, or by an approved independent testing laboratory under the direction of a registered professional Civil Engineer, licensed by the State of Tennessee. The concrete plant technician or the Civil Engineer shall certify that the information contained on the design is correct and is the result of information obtained from the trial batches. Prepare trial batches for design, including admixtures in the proper proportion, no more than 90 days before the design submittal. The approved mix design will expire after 6 months if it is not used on a Department-funded project and meet the minimum 28-day requirements. All cost of concrete design, preparation, and submittal are the Contractor's responsibility.

2. Design and Production Parameters. The concrete design shall be air entrained and produce a workable concrete mix meeting the design and production parameters specified in Table 501.03-1.

Table 501.03-1: Class CP – Paving Concrete

28 Day Compressive Strength, min (PSI)	Minimum Cementitious Content (pounds per cubic yard)	Maximum Water/Cement Ratio (pound/pound)	Air Content (%)	Slump (inch)
3000	526 [1] 545 [2]	0.49	5% design 3 – 8% production	0 - 2 [3] 3 ± 1 [4]

(1) 526 pounds required when the coarse aggregate is crushed stone

(2) 545 pounds required when the coarse aggregate is gravel

(3) Allowable slump for slipform paving

(4) Allowable slump for other than slipform paving

The fine aggregate shall not exceed 44% by volume calculation of the total aggregate.

The Contractor may include chemical admixtures in the concrete mixture as specified in Table 501.03-2 based on the ambient air temperature and expected weather conditions.

Table 501.03-2: Chemical Admixtures

Class of Concrete	Temperature less than 85 °F and falling	Temperature 85 °F or greater and rising
CP	Type A or Type F	Type D or Type G

Admixtures to be incorporated into the concrete shall all be from the same manufacturer, and shall be incorporated into the concrete according to the manufacturer's recommendations, subject to the Engineer's approval.

3. Mix Design Submittal. Include the following information as a minimum in the proposed concrete design submittal :

1. Source of all aggregate

2. Brand and type of cement
3. Source and class of fly ash (if used)
4. Source and grade of ground granulated blast furnace slag (if used)
5. Specific gravity of cement
6. Specific gravity of fly ash (if used)
7. Specific gravity of ground granulated blast furnace slag (if used)
8. Admixtures (if used)
9. Gradation of aggregates
10. Specific gravities of aggregates (saturated surface dry)
11. Air content (if air entrainment is used)
12. Percentage of fine aggregate of the total aggregate (by volume)
13. Slump
14. Weight per cubic yard
15. Yield
16. Temperature of plastic concrete
17. Water/cement ratio (pound/pound)
18. 7-day compressive strength [minimum of two 6-inch x 12-inch cylinders]
19. 14-day compressive strength [minimum of two 6-inch x 12-inch cylinders]
20. 28-day compressive strength [minimum of two 6-inch x 12-inch cylinders]
21. Weight of each material required to produce a cubic yard of concrete

Instead of the above mix design submittal, the Contractor may submit for approval a request to use an existing design (Contractor or Department prepared) approved by the Department within the current calendar year. The approval of this concrete design submittal will not relieve the Contractor of the responsibility of providing concrete meeting the requirements of these Specifications. A temporary mix design may be issued if the 7-day or 14-day compressive strengths exceed the required 28-day strengths.

If proposing to use materials or admixtures from sources other than those shown on the approved concrete mix design, submit a written request to the Regional Materials and Tests Engineer explaining the necessity for the change and include a new mix design developed in accordance with this Subsection **501.03**. Do not

place any concrete until the new design is approved. The Engineer will not accept concrete produced using materials that are not shown on an approved concrete design.

4. Partial Cement Replacement with Fly Ash or Ground Granulated Blast Furnace Slag

a. General. In addition to the option to use Type IS cement, the Contractor may have the option to replace a portion of Type I or Type IL cement in Portland cement concrete, up to a maximum specified herein, with fly ash, ground granulated blast furnace slag, or both. It is the Contractor's responsibility, if choosing to use fly ash, ground granulated blast furnace slag, or both as a partial cement replacement, to provide Portland cement concrete of the design strengths specified in all applicable special provisions, on the Plans, or in the Standard Specifications. Do not use Type IS cement in concrete when high early strength is specified. Do not use Type I or Type IL cement with fly ash or ground granulated blast furnace slag as a partial cement replacement when high early strength is specified.

When choosing to replace a portion of Type I or Type IL cement with fly ash, ground granulated blast furnace slag, or both, ensure that the following requirements will be met before producing any Portland cement concrete:

1. Store fly ash or ground granulated blast furnace slag in silos separate from each other and separate from the Type I or Type IL cement.

2. Add the fly ash or ground granulated blast furnace slag to the concrete using methods and equipment approved by the Engineer and capable of uniformly distributing the materials throughout the mix.

3. The fly ash or ground granulated blast furnace slag may be weighed cumulatively in the weigh hopper with the cement, if the cement is added first. The temperature of the fly ash or the ground granulated blast furnace slag shall not exceed 160 °F when introduced to the mix.

4. Closely monitor the mix to maintain a consistent air content between 3% and 8%.

b. Additional Testing. The Department may require additional testing to verify the desired properties of Portland cement concrete with fly ash or ground granulated blast furnace slag. The Department will not pay for the expense or lost production due to the additional testing. Examples of additional testing the Department may require include:

1. Additional air testing the Engineer determines to be necessary to monitor the entrained air due to fluctuations in LOI and fineness of the fly ash or ground granulated blast furnace slag material.

2. Additional compressive test specimens to determine strengths for form removal due to the slowed strength development inherent with fly ash or ground granulated blast furnace slag concrete.

c. Mix Design with Type I or Type IL Cement Modified by Fly Ash or Ground Granulated Blast Furnace Slag. The design of Portland cement concrete with Type I or Type IL cement can be modified by the addition of fly ash or ground granulated blast furnace slag. Table 501.03-3 indicates the maximum cement replacement rates (by weight) and minimum substitution ratios (by weight) for the type of modifier specified.

Table 501.03-3: Type I or Type IL Cement Modified by Fly Ash or Ground Granulated Blast Furnace Slag (GGBFS)

Modifier	Maximum Cement Replacement Rate % (by weight)	Minimum Modifier Cement Substitution Rates (by weight)
GGBFS (grade 100 or 120)	35.0	1:1
Class “F” Fly Ash	25.0	1:1
Class “C” Fly Ash	25.0	1:1

d. Ternary Blends. The Contractor may use ternary cementitious mixtures (mixtures with Portland cement, ground granulated blast furnace slag, and fly ash) for Class CP Concrete so long as the minimum Portland cement content is 50%. The maximum amount of fly ash substitution in a ternary blend shall be 20%. Substitution rates shall be at a 1:1 ratio.

5. Use of Class A Concrete. If approved by the Engineer, the Contractor may use Class A Concrete, as specified in **604** and modified herein, in variable width sections, ramps, and on projects containing 10,000 square yards of concrete pavement or less. The slump shall be modified to be a maximum of 3 inches, and the compressive strength of cylindrical specimens molded, cured and tested in an approved laboratory shall be not less than 3,000 psi at 28 days. The Department will not make additional payment to the Contractor for increased costs due to the use of this mixture.

6. Adjustments to Mix Proportions. Meet the mix proportions approved by the Department during the progress of the work, except make the following adjustments as necessary with the Engineer's approval:

1. Maintain the cement content within 2% of the designated value by adjusting the proportions of materials as necessary.

2. If concrete of the desired plasticity and workability cannot be obtained with the proportions originally designed, adjust the aggregate weights as required, provided that the originally designated cement content is not changed except as specified in paragraphs (3), (4) and (5) below.

3. If it is found impossible to produce concrete having the required consistency without exceeding the maximum allowable water-cement ratio specified, increase the cement content so that the maximum allowable water-cement ratio will not be exceeded.

4. If for any reason the concrete must be placed by hand methods and the water-cement ratio established for the vibrated concrete cannot be maintained, adjust the mix proportions for placement by hand methods and increase

the cement proportion by 38 pounds per cubic yard, or more if necessary, in order to maintain the water-cement ratio established for the vibrated concrete. The Department will not make additional payment to the Contractor for the cost of the additional cement.

5. Change the mix proportions if the character or source of materials changes.

6. Change the mix proportions or mixing procedure to maintain the air content within the specified limits.

7. Change the mix proportions to allow for the use of retarders or other chemical additives that may be required or approved.

B. Quality Control and Acceptance of Concrete

It is the Contractor's responsibility to determine and measure the batch quantities of all ingredients (including all water and specified or approved admixtures) for all concrete produced for the Project, and to mix, deliver, and place the concrete so that the concrete meets the requirements of these Specifications. The minimum size of a batch shall be 2.5 cubic yards.

Provide qualified technicians to perform sampling, testing, and inspection for process control. A TDOT Class 2 or higher concrete plant technician shall provide process control of the concrete at the concrete plant. This technician shall be present at the concrete plant during all batching operations for the Project and shall have the primary responsibility during production of performing process control. A concrete technician holding a TDOT Class 1, ACI Class 1, or higher certification shall provide process control of the concrete at the placement site and shall be present during all concrete placement. A TDOT or ACI certified Class 1 or higher technician is not required to be at the placement site during small quantity placing operations but shall perform one complete set of tests during the life of the Project.

Provide the necessary equipment to perform process control at the plant and at the placement site during times of concrete placement.

For process control, perform the following as a minimum:

1. Test to determine aggregate gradations (AASHTO T 27 with AASHTO T 11 when required).

2. Frequently inspect the stockpiles to ensure they remain uncontaminated and unsegregated. Maintain a current aggregate quality report at the plant.

3. Calibrate the weighing systems, water meters, and admixture dispensing systems before starting production.

4. Ensure accurate weighing of the aggregates and cement, the proper metering of water and admixtures, and the quality of water.

5. Ensure mixing equipment is in proper working condition and the proper mixing speeds and revolutions are controlled as required by the Specifications and the Materials and Tests Standard Operating Procedures.

6. Adjust mix proportions due to actual moisture content of both coarse and fine aggregates, with moisture content determined according to AASHTO T 255.

7. Conduct slump (AASHTO T 119) and air tests (AASHTO T 152).

8. Conduct yield tests (AASHTO T 121). If yield varies more than plus or minus 2% from that shown on the design, stop all batching operations until the problem has been identified and corrected or a new concrete design has been obtained.

9. Prepare quality control cylinders and early break cylinders (7-14 day, etc.) for compression tests performed according AASHTO T 22.

10. Conduct tests for concrete and ambient air temperatures.

11. Provide a daily report to the Engineer that identifies the date, Contract and Project, Item number(s), batch weights, moisture corrections, admixtures, slump, air content, temperatures, and similar pertinent information. The Engineer will provide a sample daily report to the Contractor.

12. A concrete delivery ticket shall accompany each load to the placement site. The ticket shall include as a minimum the following:

    a. Date
    b. Contract number
    c. County
    d. Class of concrete
    e. Concrete design number
    f. Number of cubic yards
    g. Load number
    h. Truck number
    i. Maximum water allowed by design
    j. Total water added at the plant
    k. Maximum water allowed to be added on the project
    l. Actual water added on project
    m. Number of revolutions at mixing speed at plant
    n. Number of revolutions at mixing speed at project
    o. Time loaded
    p. Time discharged
    q. Actual and target batch weights of each component including each aggregate, chemical admixture and mineral admixture used

The concrete producer shall develop for the Engineer's approval and maintain at the plant a plant-specific Process Control Plan that shall apply to all Department contracts for the calendar year. Communicate all changes made to the Process Control Plan during the year to the Regional Materials Supervisor. Develop for the Engineer's approval a placement site Process Control Plan stating the procedures for sampling, testing, and inspection of the concrete. Maintain a record of all tests and inspections performed at the plant site and placement site. Provide these documents to the Engineer upon completion of the Project for inclusion in the Project records. Keep records current and make them available to the Engineer for review at any time.

Make, cure, and transport all early break cylinders (7-14 day, etc.) according to AASHTO T 23, and deliver to the Regional laboratory or other established satellite laboratories for testing.

The Department or its representative will be responsible for performing all acceptance tests. A TDOT Level 1 Certified or ACI Certified Technician will sample, test air content and slump, and prepare 28-day

cylinders for acceptance testing. The Department will also be responsible for properly curing and transporting all acceptance cylinders according to AASHTO T 23.

The Department will perform all independent assurance sampling and testing. All sampling and testing for acceptance and independent assurance will be at the frequencies established in the Department's Standard Operating Procedures. The Department will determine the time and location for obtaining all acceptance and independent assurance samples.

Provide cylinder molds, a wheelbarrow, and a level site to perform testing and for initial curing. Provide a secure storage shed/building for temporary storage of concrete acceptance cylinders as specified in **722.09**.

Correct batch weights to compensate for surface moisture on the aggregate at the time of use. The Contractor may withhold some of the water from the mix at the plant provided the delivery ticket indicates the amount of water withheld. If a portion of the water is withheld at the plant, the Contractor may add additional water at the work site provided the design water/cement ratio of the mix is not exceeded.

EQUIPMENT

501.04 Equipment

Obtain the Engineer's approval as to the design, capacity, and mechanical condition of equipment and tools used to handle materials and perform all parts of the Work. Have the equipment at the jobsite sufficiently ahead of the start of construction operations to allow the Engineer to perform a thorough examination.

A. Batching Plant and Equipment

1. **General.** The batching plant shall include bins, weighing hoppers, and scales. If using cement in bulk, include a bin, hopper, and separate scale for cement. Provide adequate means for cement cut off checks. Ensure that the weighing hoppers are properly sealed and vented to preclude dusting during operation. Provide adequate means to sample the cement stored in the bulk cement storage bin or hopper.

2. **Bins and Hoppers.** Provide bins with adequate separate compartments for fine aggregates, each size of coarse aggregate, and cement in the batching plant. Ensure that each compartment discharges efficiently and freely into the weighing hopper. Provide controls so that as the quantity desired in the weighing hopper is being approached, the material may be added slowly and shut off with precision. Provide a port or other opening for removing an overload of any one of the several materials from the hopper. Provide weighing hoppers that are constructed to eliminate accumulations of tare materials and to discharge fully without jarring the scales. Ensure that the partitions between compartments, both in bins and in hoppers, are sufficiently ample to prevent spilling under any working conditions.

3. **Scales.** Provide scales of the beam type, springless, dial type or load cell type to weigh aggregates, cement, and pozzolans. Scales shall be accurate within 0.5% throughout the range of use. Scale dial faces or digital readouts are to be graduated to indicate loads of 0.1% or less of scale capacity.

   When using beam type scales, provide an indicator such as a "tell-tale" dial to inform the operator that the required load in the weighing hopper is being approached. The "tell-tale" device on weighing beams shall clearly indicate the critical position. Poises shall be designed so that they cannot be easily removed from the beam and can be held firmly in place. Ensure that the weigh beams and "tell-tale" device are in full view of the operator while charging the hopper and that the operator has convenient access to all controls.

   Inspect and check the scales as often as the Engineer deems necessary to assure their continued accuracy. Have at least ten standard 50-pound weights, meeting the requirements of the U.S. Bureau of Standards, available for calibrating and testing weighing equipment, and be calibrated by a certified scale company every 6 months.

B. Mixers

1. **General.** The Contractor may mix concrete at the site of construction or at a central point or wholly or in part in truck mixers. Each mixer shall have attached in a prominent place a manufacturer's plate showing the capacity of the drum, in terms of

mixing and agitating capacity, and the speed of rotation of the mixing drum or blades for both mixing and agitation.

Mixers shall be capable of combining the aggregates, cement, additives when specified, and water into a thoroughly mixed and uniform mass within the specified mixing period. They shall have sufficient capacity to comply with minimum production requirements.

Equip mixers with an approved device for accurately measuring water within a range of error of not more than 1%. Provide an accurately calibrated and easily read indicator to show the amount of water used in each batch.

Equip central plant mixers and mixers at the site of construction with an approved batch meter and timing device that will automatically lock the discharge lever during the full time of mixing and release it at the end of the mixing period. This device shall be equipped with a bell or other suitable warning device that will give a clearly audible signal each time the lock is released. If the timing device fails, the Contractor may use the mixer for the balance of the day while it is being repaired, provided the Contractor has a satisfactory means of determining the mixing time.

All mixers shall have blade wear indicators. Repair the pick-up and throw-over blades in the drum or drums once the blade wear reaches the blade wear indicator or when holes are worn through the blades. Place the top of the blade wear indicator at 90% of the total height of the radial part of the blade. Retain at the jobsite or central plant a copy of the manufacturer's design showing dimensions and arrangements of blades. The blade wear indicator shall be a minimum of 1/4 inch thick steel, 2 inches wide by 6 inches long. Locate the indicators as shown in the Division of Materials and Test, Circular D-9.

2. **Mixers at Site of Construction.** In addition to the above requirements, mixers at the site of construction, unless otherwise stipulated, shall also meet **105.17** and shall be capable of discharging and distributing the mix without segregation on the prepared subgrade or sub-base.

3. **Truck Mixers and Truck Agitators.** Ensure that truck mixers used for mixing and hauling concrete, as well as the truck agitators used for hauling central-mixed concrete, meet all the applicable requirements specified in **501.04.B.1**, and in addition, have a manufacturer's plate indicating the various uses for which the equipment is designed, the gross volume of the drum, and the minimum and maximum speed of rotation of the drum or blades for charging, mixing and agitating. Equip trucks used for mixing with an approved device for recording the number of revolutions of the drum or blades. Mixers or agitators used to mix and transport paving concrete shall be of the hydraulic drum lift type or other specially designed types that will discharge low slump concrete 1/2 to 1-1/2 inches at a satisfactory rate without segregation. The Contractor may use approved conventional or standard truck mixers or truck agitators for mixing and hauling concrete under **604**, for projects that contain 10,000 square yards or less of concrete paving.

4. **Non-agitator Trucks.** Bodies of non-agitator hauling equipment for concrete shall be smooth, mortar-tight, metal containers, and shall be capable of discharging the concrete at a satisfactorily controlled rate without segregation. Provide covers to protect the concrete.

C. Forms

Use straight side forms of metal having a thickness of not less than 7/32 inch and furnished in sections not less than 10 feet in length. Forms shall have a depth at least equal to the required edge thickness of the concrete, without horizontal joint, and a base width equal to at least the depth of the forms. For curves of 100-foot radius or less, use flexible or curved forms of wood or metal, of the proper radius, and of a design acceptable to the Engineer. Provide forms with adequate devices for secure setting so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Flange braces shall extend outward on the base not less than 2/3 the height of the form. Ensure that the top face of the form does not vary from a true plane by more than 1/8 inch in 10 feet, and the face of the form does not vary more than 1/4 inch. The forms shall contain provisions for locking the ends of abutting form sections together tightly, and for secure setting. Metal pins shall be of proper size and length to hold the forms rigidly and securely in place.

Do not use built-up forms except where the total area of pavement of any specified thickness on the Project is less than 10,000 square yards. Built-up forms shall have a minimum base width of 8 inches.

Remove forms with battered top surfaces and forms that are bent, twisted, or broken. Do not use repaired forms until inspected and approved by the Engineer.

Provide and maintain in satisfactory condition an adequate supply of forms to meet the needs of a full day's run.

D. Spreading and Finishing Equipment

Equipment shall include a paving machine designed to uniformly vibrate and finish the concrete full width and to its final grade.

1. **Vibrators.** Vibrators for full-width and full-depth vibration of concrete paving slabs shall be multiple spuds or other types approved by the Engineer. Either attach the vibrators to the spreader or the finishing machine, or mount them on a separate carriage. Operate the vibrators at the frequency recommended by the manufacturer, subject to approval of the Engineer. Submit to the Engineer the manufacturer's recommendations for installing and operating vibrators.

2. **Longitudinal Floats.** Provide a mechanical longitudinal float, of a design approved by the Engineer, which is in good working condition and constructed to allow accurate adjustment to the required crown.

3. **Bridges.** Furnish a minimum of two individual work bridges.

4. **Finishing Straightedge.** Provide at least two straightedges, with handles at least 3 feet longer than half the width of the slab, constructed of light metal, and not less than 10 feet long. Ensure that the straightedges remain clean and straight.

5. **Straightedge Templates.** Provide at least two straightedge templates for testing the completed surface. They may be of wood or metal; shall not be less than 12 feet long; and shall be clean, straight, and free from warp.

6. **Water Supply Equipment.** Water supply equipment shall include pumps, or tanks mounted on trucks, of adequate capacity to furnish more than sufficient water to accommodate the construction and at the required and necessary pressure. A pipe line appropriate to the requirements of the construction may be used.

7. **Small Tools.** Provide edgers, trowels, hand floats, brushes, and other small tools necessary to produce the results required.

8. **Special Equipment and Tools.** Equipment and tools necessary to construct special features as shown on the Plans shall be able to produce the results required.

9. **Transverse Grooving Equipment.** Mechanical transverse grooving equipment shall consist of a steel tine comb with a minimum width of 6 feet, a vibrating beam roller, or other approved devices.

10. **Concrete Saw.** If sawed joints are elected or specified, provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions and at the required rate. The saws shall be equipped with water-cooled diamond edge blades. For sawing longitudinal joints, use saws equipped with guides to ensure proper alignment of the joints.

    Provide at least one standby saw in good working order. Maintain an ample supply of saw blades onsite at all times during sawing operations. Provide adequate artificial lighting facilities for night sawing. Have all of this equipment onsite both before and continuously during concrete placement.

11. **Slip-form Paver.** Provide slip-form pavers designed to spread, consolidate, screed, and float-finish freshly placed concrete in one complete pass of the paver so that only a minimum of hand finishing will be necessary to provide a dense and homogeneous pavement that conforms with the Plans and Specifications. The slip-form paver shall be an approved self-propelled type, equipped with a crawler type track of sufficient area to prevent track slippage under load or sinking into the supporting subbase/subgrade. The length of ground contact per track and arrangement of track units shall be adequate to ensure the established straightedge tolerance. When using slip-form pavers,

comply with all provisions and requirements of these Specifications that do not conflict with slip-form construction.

Control pavement alignment with an electronic sensing device in continuous contact with a sensing guide. Furnish equipment with electronic controls for vertically adjusting the paver strike-off and finishing components. Provide, install, and maintain electronic controls, sensing devices, and sensing guides at no additional cost to the Department.

CONSTRUCTION REQUIREMENTS

501.05 Subgrade Preparation

Prepare the subgrade as provided for under **207**.

501.06 Construction of Base

Construct the base as specified in the applicable Section of Part 3 – Bases and Subgrade Treatments, of these Specifications.

Construct the base to such grade tolerances as will ensure the required concrete pavement thickness is obtained.

Complete the base at least 500 feet in advance of paving.

Equip the base grading machine and slip-form paver with automatic line (guidance) and grade controls.

501.07 Setting Forms

A. Base Support

Ensure that the foundation under the forms is firm and true to grade so that each form, when set, will be firmly in contact for its whole length and at the specified grade. Fill all grade at the form line, which is found to be below established grade, up to grade with suitable material in lifts of 1/2 inch or less for a distance of 18 inches on each side of the base of the form, and thoroughly compact the material. Correct all grade at the form line found to be above grade by tamping or cutting as necessary. Do not rest the forms on pedestals of earth or other material to bring them to grade.

B. Form Setting

Set and obtain approval of forms a minimum of 500 feet in advance of the point where concrete is being placed. The Contractor may reduce this distance as approved by the Engineer when prevailing conditions justify a shorter distance. After setting the forms to the correct grade, thoroughly tamp, mechanically or by hand, the material supporting the forms, at both the inside and outside edges of the base of the forms. Stake forms into place with not less than three pins for each 10-foot section. Place a pin at each side of every joint. Ensure that form sections are tightly locked and free from play or movement in any direction. Do not allow the forms to deviate from true line by more than 1/4 inch at any point. Reset or remove as directed forms that settle or spring under the spreading and finishing equipment. Clean and oil the top and face of forms before placing concrete.

C. Grade and Alignment

Immediately before placing the concrete, check the alignment and grade elevations of the forms and correct as necessary. When a form has been disturbed or a grade has become unstable, reset and recheck the affected form.

501.08 Conditioning of Base

Check and correct the grade immediately ahead of concrete placing operations. Use an approved machine with automatic grade control to attain the final section. If the slip-form method of paving is used, place, compact, and finish the base to the proper grade to a width beyond the pavement limits sufficient to support all paving equipment.

Remove and replace high areas. The Contractor may fill low areas with base material and compact to correspond with the surrounding areas; except that for low areas in cement treated bases and bituminous bases, fill with concrete integral with the pavement. Repair low areas in lean concrete base as directed by the Engineer.

The base shall have been previously wetted, and shall be in a moist condition at the time of placing concrete. If the base subsequently becomes dry before the actual placing of concrete, sprinkle it, while taking care to avoid forming pools of water. The base shall not be muddy or soft.

501.09 Handling, Measuring, and Batching Material

Ensure that the batch plant site, layout, equipment, and provisions for transporting material will provide a continuous supply of material to the work. Build and maintain aggregate stockpiles as specified in **903.20**. A concrete delivery ticket shall accompany each load to the placement site and shall include, as a minimum, the information specified in **501.03.B.12**.

Handle and transport aggregates from stockpiles or other sources to the batching plant in such a manner as to maintain a uniform grading of the material. Do not use aggregates that have become segregated or mixed with earth or foreign material. Stockpile or bin all aggregates produced or handled by hydraulic methods at least 12 hours before being batched to allow for drainage. Consider rail shipment requiring more than 12 hours as adequate binning only if the car bodies allow free drainage. If the aggregates contain high or non-uniform moisture content, the Engineer may require storage or stockpile periods in excess of 12 hours, or sprinkling of aggregate to achieve uniform moisture content.

Separately weigh the fine aggregate and each size of coarse aggregate into the hopper or hoppers in the respective amounts set by the Engineer. The course aggregates shall meet the gradation requirements for Size No. 467, as specified in **903.22**, or a blend of Size No. 4 and Size No. 67 that meets the required gradation for Size No. 467, specified in **903.22**.

Measure cement by weight, using separate scales and hoppers. The scales shall be equipped with a device to indicate positively the complete discharge of the batch of cement into the batch box or container.

The Contractor may use batching plants equipped to proportion aggregates and bulk cement by weight by means of automatic and interlocked proportioning devices of the approved type.

The tolerance of the individual quantity of each cementious material shall be no less than 1% below or more than 4% above the required weight. Weigh aggregates within a tolerance of 1.5% of the required weight.

When mixing is at the site of construction, transport aggregates from the batching plant to the mixer in batch boxes, vehicle bodies, or other containers of adequate capacity and construction to properly carry the volume required. Ensure that partitions separating batches are adequate and effective to prevent spilling from one compartment to another while in transit or being dumped.

For bulk cement, use a suitable method of handling the cement, from weighing hopper to transporting container, for transportation to the mixer, with chute, boot, or other approved device, to prevent loss of cement and to provide positive assurance of the actual presence in each batch of the entire amount specified.

Transport bulk cement to the mixer in weatherproof compartments carrying the full amount of cement required for the batch. The Contractor may transport cement in original shipping packages on top of the aggregates, with each batch containing the proportion required by the job mix.

Deliver batches to the mixer separate and intact. Dump each batch into the mixer without loss of any material, and when more than one batch is carried on the truck, without spilling of material from one batch compartment to another.

The Contractor may measure water either by volume or by weight. The accuracy of measuring the water shall be within a range of error of not more than 1%. Unless otherwise allowed, calibrated tanks for measuring water shall include an auxiliary tank from which the measuring tank shall be filled. The measuring tank shall be equipped with an outside tap and valve to check the setting unless other means are provided for readily and accurately determining the amount of water in the tank. The volume of the auxiliary tank shall be at least equal to that of the measuring tank.

Use chemical additives as specified in **501.02**, and add them to the mix using the methods and in the manner recommended by the manufacturer, subject to the Engineer's approval.

Add air-entraining agents to the mix using an approved procedure and an approved dispenser to ensure accurate proportioning of the agent.

Measure all admixtures to an accuracy of plus or minus 3%.

501.10 Mixing Concrete

The Contractor may mix concrete in a central-mix plant or in truck mixers. The mixer shall be of an approved type and capacity, and shall comply with the applicable requirements of **501.04.B**. Clean mixers at suitable intervals to prevent buildup of hardened concrete that could affect the mixer's capacity and mixing ability.

Dump the batch into the drum so that a portion of the mixing water enters in advance of the cement and aggregates. Measure mixing time from the time all materials, except water, are in the drum. Ensure that the flow of water is uniform, and that all water is in the drum by the end of the first 15 seconds of the mixing period. Keep the throat of the drum free of accumulations that may restrict the flow of materials into the drum.

When mixed in a concrete paver at the site of construction or in a central mixing plant, ensure that the mixing time is no less than 60 seconds and no more than 90 seconds. Mixing time ends when the discharge chute opens. Include transfer time in multiple drum mixers in the mixing time. Remove the contents of an individual mixer before a succeeding batch is emptied therein.

Operate the mixer at the speed recommended by the manufacturer. Dispose of concrete mixed less than the specified time at no additional cost to the Department. Do not operate mixers for central-mix plants at a capacity greater than the manufacturer's guaranteed mixing capacity.

Transport mixed concrete from the central mixing plant in truck mixers, truck agitators, or non-agitating trucks having special bodies. Truck mixers and truck agitators used to transport concrete from a central mixing plant and truck mixers used to mix concrete in transit from a central batching plant shall meet all applicable requirements of **501.04.B.3**, and in addition, the mixing speed and agitating speed shall be those recommended by the manufacturer of the mixer, and the total revolutions at mixing speed shall be within the range of 70 to 100 for drum mixers. Operate truck mixers and truck agitators within the capacity recommended by the manufacturer. When truck mixers are used on hauls in excess of 1 hour, add the cement at the site of construction and perform mixing as specified under this Subsection.

From the time water is added to the mix to the time the concrete is deposited in place, no more than 30 minutes shall elapse for concrete hauled in non-agitating trucks, and no more than 60 minutes shall elapse for concrete hauled in truck mixers or truck agitators.

The Engineer will not allow retempering of concrete by adding water or by other means; however, the Contractor may withhold a portion of the mixing water from transit mixers and add at the work site, provided the delivery ticket indicates the amount of water withheld. Mix the batch for 30 revolutions at mixing speed after adding the water. Do not add water to a partial load of concrete mix. Do not use concrete that is not within the

specified slump limits at time of placement. Only use admixtures for increasing the workability or for accelerating the set when provided for in the Contract or approved by the Engineer. Add admixtures to the mix as specified in **501.09**.

Perform tests for air content on samples of fresh concrete when and as directed, and in accordance with AASHTO T 152 or T 196. The air content shall meet **501.03**.

501.11 Mixing Limitations

Stop mixing concrete in time to allow finishing to be completed in daylight hours, unless an adequate and approved artificial lighting system is provided and operated.

Unless authorized in writing by the Engineer, discontinue mixing and concreting operations when falling air temperature in the shade and away from artificial heat reaches 40 °F. Do not resume operations until rising air temperature in the shade and away from artificial heat reaches 35 °F.

When concreting at temperatures above 35 °F, heat or cool the aggregates or water as necessary before placing in the mixer so that the temperature of the resultant mixture will be no less than 50 °F and no more than 90 °F at the time of placement. If heating is required, use an apparatus that will heat the mass uniformly and that will prevent the possible occurrence of overheated areas that might damage the concrete. Do not use frozen aggregates in the concrete.

When concreting is authorized at temperatures of 35 °F or less, heat the water or the aggregates or both to no less than 70 °F and no more than 150 °F. Ensure that the temperature of the heated mixture is no less than 60 °F and no more than 100 °F at the time of placement on the road.

501.12 Placing Concrete

Either unload the concrete into an approved spreading device, or deposit it directly on the base, and mechanically spread the concrete in a manner that prevents segregation of the materials. When using central or transit mixed concrete, deposit it in an approved spreader. Place the mixture so as to minimize rehandling and relocation from point of placement. The mechanical spreader will not be required on areas too small to accommodate the paving equipment, projects that contain 10,000 square

yards or less of concrete paving, and on variable width sections and ramps. Placing shall be continuous between transverse joints without the use of intermediate bulkheads. Do not place concrete on frozen grade.

Perform any necessary hand spreading with shovels or other approved tools. Do not allow workmen to walk in the freshly mixed concrete with boots or shoes coated with earth or other foreign substances.

If placing concrete adjacent to a previously constructed lane of pavement and mechanical equipment is to be operated on this existing lane of pavement, that lane shall meet the requirements for opening to traffic specified in **501.22**. If the existing lane is to only carry finishing equipment, the Contractor may begin paving the adjoining lanes after 7 days.

Use vibrators to thoroughly consolidate the concrete against and along the faces of all forms and along the full length and on both sides of all joint assemblies. Do not allow vibrators to come in contact with a joint assembly, the grade, or a side form. Do not operate the vibrator for longer than 5 seconds in any one location.

The Contractor may only use hand-operated vibrators on projects containing 10,000 square yards or less of concrete paving and on variable width sections. Only operate vibrators mounted on a machine while the machine is in motion.

Deposit concrete as near to expansion and contraction joints as possible without disturbing them; do not dump concrete from the discharge bucket or hopper onto a joint assembly unless the hopper is well centered on the joint assembly.

Immediately remove all concrete materials that may fall on or be worked into the surface of a completed slab using approved methods.

When using the slip-form method of concrete paving, place the concrete with an approved slip-form paver meeting the requirements of **501.04.D.11**. Equip the slip-form paver with vibrators meeting the applicable requirements of **501.04.D.1** to vibrate the concrete for the full width and depth of the strip of pavement being placed.

Ensure that the sliding forms are rigidly held together laterally to prevent spreading of the forms. The forms shall trail behind the paver for such a distance that no appreciable slumping of the concrete will occur and so that

necessary finishing can be accomplished while the concrete is still within the forms. Before the concrete has hardened, correct any edge slump of the pavement, exclusive of edge rounding, in excess of 1/4 inch.

Operate the slip-form paver with as nearly a continuous forward movement as possible, and coordinate all operations of mixing, delivering, and spreading of concrete so as to provide uniform progress while minimizing the stopping and starting of the paver. If, for any reason, it is necessary to stop the forward movement of the paver, also immediately stop the vibratory and tamping elements. Apply no tractive force to the machine, other than that which is controlled from the machine. Replace slabs with random cracks before completion of paving operations.

501.13 Testing Concrete

All sampling and testing of materials will be performed in conformance with the Department's Policies on Sampling and Testing Procedures. During the process of work if either the slump or air consistency tests give results outside the allowable specification range, do not place any additional concrete until the slump, air content, or both is brought within specification limits.

The Engineer will determine the 28-day compressive strength of the concrete under construction by conducting tests during the progress of work in accordance with **604.15**. The method of making and curing test specimens will be in accordance with AASHTO T 23. Furnish the concrete necessary for the Engineer to conduct the field tests, and provide a storage facility with watertight tanks of satisfactory size and number to accommodate the cylinder specimens. The Engineer may allow concrete that fails to meet the specified strength to remain in place, but the Department will pay for such concrete at a reduced price as specified in **604.31** to compensate for the loss of strength. Any reduction in payment because of low strength will be in addition to any reduction in payment related to deficiencies in pavement thickness or rideability.

The Engineer will determine pavement thickness from test cores drilled by the Contractor from each unit of pavement in accordance with **501.24**.

501.14 Strike-Off of Concrete and Placement of Reinforcement

Following the placing of concrete, strike it 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 in

reasonably close conformity with the elevation shown on the Plans or established by the Engineer. When reinforced concrete pavement is placed in two layers, strike off the entire width of the bottom layer 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. When steel fabric is indicated, place it in strips transverse to the roadway at the depth and with the lap shown on the Plans. The fabric shall extend to within 2 inches of the ends and sides of the slab. Place the reinforcement directly on the concrete, and then place, strike off, and screed the top layer of the concrete. Remove and replace with freshly mixed concrete, at no cost to the Department, all portions of the bottom layer of concrete left in place for more than 30 minutes without being covered with the top layer. When reinforced concrete is placed in one layer, the Contractor may position reinforcement in advance of concrete placement, or place it after spreading the concrete by mechanical or vibratory means.

Ensure that reinforcing steel is free from dirt, oil, paint, grease, mill scale, and loose or thick rust that could impair the bond of the steel with the concrete.

501.15 Joints

Construct joints of the type and dimensions and at the locations shown on the Plans and in accordance with these Specifications.

Unless otherwise specified or directed, all contraction and construction joints shall be of the plain sawed groove type.

A. Longitudinal Joints

Install longitudinal joints perpendicular to the pavement surface and along or parallel to the center-line of the pavement, unless otherwise specified.

Place deformed steel tie bars of the specified length, size, spacing, and materials across and perpendicular to the longitudinal joints. Place the tie bars using approved mechanical equipment or rigidly secure them by chairs or other approved supports to prevent displacement. When using the slip-form method of paving, place the tie bars before vibrating.

To install tiebars in existing hardened concrete, pre-drill holes into the existing concrete slab to a minimum depth of half the tie-bar length and

to a diameter of no more than 1/8 inch greater than the tie-bar. Thoroughly clean all pre-drilled holes using a wire brush and compressed air. Secure the tiebars using epoxy or adhesive material capable of withstanding minimum average pull-out resistance of 12,000 pounds or a maximum slippage of 1/32 inch. Provide jacking equipment or other suitable means to test the tiebars to meet the minimum pull-out resistance to the satisfaction of the Department.

A representative test section of a minimum of 15 tiebars or 2% of the total amount used on the Project shall be tested to determine if the installation method is acceptable. The Engineer will base acceptance on the pull-out data of this test section. The Engineer may require more than one test section if the Contractor's methods and procedures vary from the original procedure or there is reason to believe the installation is faulty.

Include all costs involved in the above procedure in the price bid for concrete pavement.

Cut longitudinal sawed joints with approved concrete saws to the depth, width, and line shown on the Plans, not later than 10 days after placing concrete and before any equipment or vehicles are allowed on the pavement.

Immediately after sawing, thoroughly clean all longitudinal contraction and construction joints of all residue by flushing with water under pressure.

B. Transverse Expansion Joints

Construct transverse joints to be straight, vertical to the pavement surface, and at the angle to the center-line of the pavement shown on the Plans.

Provide dowels across transverse expansion joints as shown on the Plans.

Secure dowels in position, parallel to the surface and centerline of the slab, with an approved metal device that is left in the slab. Unless otherwise specified, paint dowels with one coat of approved primer and thoroughly coat with a thin film of oil or approved bond breaker. If using oil, apply it after the paint has dried and immediately before placement. If corrosion resistant dowels are specified, use the bond

breaker recommended by the dowel or coating manufacturer or as directed by the Engineer. Cover one end of each dowel with a close fitting, closed-end metal or plastic sleeve, not less than 4 inches long. Provide a flange or other approved device to separate the end of the sleeve and the end of the dowel during the placing of the concrete so that a space of not less than the proposed thickness of the joint plus 1/4 inch will be provided for subsequent movement of the dowel in the sleeve. Use a sleeve type on the dowel bars that meets the Engineer's approval. Dowels shall have ends free from burrs and distortions. Cut wires of dowel baskets before concrete placement.

To install premolded joint filler, if specified, the Contractor may use either of the alternate expansion joint and dowel assembly devices shown on the Plans or other approved expansion joint assemblies. The installing device shall have a length of 1/2 inch less than the width of the slab. Assemblies shall be a rigid metal device capable of holding dowels and filler firmly in position during the entire construction operation and shall remain in place. Set the top of the filler below the surface of the proposed slab to accommodate the type of sealant specified, as shown on the Plans. When in position, the filler shall be perpendicular to the surface of the slab. While placing the concrete, protect the top edge of the filler with an approved metal channel cap. The Contractor may use an assembly device with a self-contained cap.

C. Transverse Contraction Joints

Place transverse contraction joints at the intervals specified and to result in the desired shape. Do not use formed contraction joints unless specified or required by the Engineer to control random cracking.

Place load transfer dowels at the intervals and depths shown on the Plans. *Unless otherwise specified,* paint dowels with one coat of approved primer and thoroughly coat with a thin film of oil or approved bond breaker. If using oil, apply it after the paint has dried and immediately before placement. If corrosion resistant dowels are specified, use the bond breaker recommended by the coating manufacturer or as directed by the Engineer.

Instead of using dowel assemblies at contraction joints, the Contractor may place dowel bars in the full width of pavement using a mechanical device approved by the Engineer. To use a dowel implanting device, first demonstrate accurate dowel placement and pavement finish.

1. **Sawing.** Begin sawing the joints as soon as concrete has hardened sufficiently to allow sawing without excessive raveling. Once started, continue with the sawing operation until all transverse contraction joints are sawed. When necessary, provide for bad weather or nighttime operations. Omit the sawing of a joint if a crack occurs at or near the joint location before the time of sawing. Discontinue the sawing of a joint when a crack develops ahead of the saw. In general, saw all joints in sequence.

   Saw all contraction joints in lanes adjacent to previously constructed lanes before uncontrolled or sympathy cracking occurs. If extreme conditions exist that make it impracticable to prevent erratic cracking by early sawing, form a contraction joint groove at intervals of every third or fourth joint or as often as required prior to initial set of concrete as provided for under paragraph (2) below. Immediately after sawing, thoroughly clean the joints of all residue by flushing with water under pressure.

   Obtain the Engineer's approval of all sawing equipment. Only use lightweight sawing equipment on the newly constructed pavement. (See **501.04.D.10**.) The Contractor may use gang saw units or similar heavy equipment if the equipment is operated from a bridge or platform supported independently of the pavement.

2. **Formed Joints.** Construct formed contraction joints during the placing of the concrete. Form these joints by placing inserts in the plastic concrete, at the angle to the centerline of the pavement shown on the Plans and perpendicular to the surface. When the concrete has attained its initial set and after the joint has been carefully finished, remove the insert. Ensure that the groove so formed maintains its full width and depth as shown on the Plans, and the pavement at the joint meets surface requirements.

D. Transverse Construction Joints

Construct transverse construction joints so as to provide a uniform surface. Provide the surface texture specified (see **501.16.G** if needed). Install transverse construction joints when an interruption of more than 30 minutes occurs during the concreting operations. Do not construct transverse joints within 10 feet of an expansion joint, contraction joint, or plane of weakness. If sufficient concrete has not been mixed at the time of interruption to form a slab at least 10 feet long, remove the excess concrete back to the previous joint and dispose of as directed.

E. Expansion Joints at Structures

Place premolded joint filler against all structures and features projecting through, into, or against the slab to form expansion joints. Such joints shall extend the full depth of slab and, unless otherwise specified, shall be 1/2 inch in width.

501.16 Final Strike-Off, Consolidation and Finishing

A. Sequence

Perform operations in the following sequence: strike-off and consolidation, floating and removal of laitance, straight-edging, and final surface finish.

B. Finishing at Joints

Consolidate concrete adjacent to joints to eliminate voids or segregation, against the joint material, under and around all load transfer devices, joint assembly units, and other features designed to extend into the pavement.

After the concrete has been placed and vibrated adjacent to the joints as specified in **501.12**, bring the finishing machine forward, operating it in a manner that will avoid damage or misalignment of joints.

C. Machine Finishing

Distribute or spread the concrete as soon as placed. Immediately after spreading, strike off and screed the concrete with an approved finishing machine that meets **501.04.D.1**. When the pan-float finisher combination machine is used for finishing the pavement, longitudinal floats are not necessary.

Vibrators, for full width and depth vibration of concrete paving slabs, shall meet **501.04.D.1**. If uniform and satisfactory consolidation of the concrete is not obtained by the vibratory method at joints, along forms, at structures, and throughout the pavement, furnish equipment and methods that will produce satisfactory work.

D. Hand Finishing

The Engineer may allow hand finishing methods in the following situations:

1. Mechanical equipment breaks down after concrete has already been deposited on the grade.

2. Variable width sections make the use of finishing machines impracticable.

When the Engineer allows hand finishing, strike-off and screed the concrete as soon as it is placed. Use a screed that is at least 2 feet longer than the maximum width of the slab to be struck off, of approved design, and sufficiently rigid to retain its shape. When reinforcement is used in the pavement, provide a strike-off template for striking off the bottom layer of concrete.

Consolidate the concrete using a suitable vibrator and other approved equipment.

Repeat screeding until the surface is of uniform appearance, true to grade and cross-section, and free from porous areas.

E. Floating

After the concrete has been struck off and consolidated, use one of the following methods to further smooth, true, and consolidate the concrete. Do not over-finish, or add water to the surface, under either of these methods.

1. Hand Method. If hand finishing is allowed as provided for under **501.16.D**, use equipment and methods approved by the Engineer.

2. Mechanical Method. Use the mechanical float described under **501.04.D.2** unless otherwise specified. Adjust the tracks from which the float operates to the required cross-section. Accurately adjust and coordinate the float with the adjustments of the transverse finishing machine so that a small amount of mortar is carried ahead of the float at all times. If excessive evaporation is occurring, the Contractor may apply a light fog spray of water. Adjust the forward speed so that the float will lap the distance directed by the Engineer on each transverse trip. Pass the float

over each area of pavement at least two times, while preventing excessive operation over a given area. Waste excess water or soupy material over the side forms on each pass.

After floating, remove excess water and laitance from the surface of the pavement with a straightedge 10 feet or more in length. Lap successive drags one half the length of the blade.

F. Straightedge Testing and Surface Correction

After the floating has been completed and the excess water removed, but while the concrete is still plastic, test the concrete surface for trueness using an accurate metal straightedge, not less than 15 feet in length, swung from handles at least 3 feet longer than half the width of the slab. Hold the straightedge in contact with the surface in successive positions parallel to the road center-line, and go over the whole area from one side of the slab to the other as necessary. Advance the straightedge along the road in successive stages of no more than half the length of the straightedge. Immediately fill depressions found with freshly mixed concrete, and strike off, consolidate, and refinish the concrete. Cut down and refinish high areas. Ensure that the surface across joints meets these straightedge requirements. Continue to perform straightedge testing and surface corrections until the entire surface is free from observable departures from the straightedge and the slab conforms to the required grade and cross-section.

If the Engineer determines superficial water is needed to assist in finishing, apply such water by lightly fogging.

G. Surface Texturing

Texture the surface using a burlap drag, consisting of a seamless strip of damp burlap which, when dragged longitudinally along the full width of pavement, produces a uniform surface of gritty texture. Maintain the drag in such condition that the resultant surface is of uniform appearance and reasonably free from grooves over 1/16 inch in depth.

After finishing the pavement by the burlap drag, texture the surface by forming transverse grooves. Form the transverse grooves with mechanical equipment using a comb made of steel tines, vibrating beam roller, or other approved device. The Contractor may use manual tools, such as rakes with spring steel tines, on areas inaccessible to

mechanical equipment, or areas of 1,000 square yards or less and variable width.

Form the grooves in the concrete at an appropriate time while the concrete is still in a plastic state, so that in the hardened concrete, the grooves will be between 0.09 and 0.13 inches in width, and between 0.12 and 0.19 inches in depth. Space the grooves at random intervals between 0.3 and 1.0 inches.

Regardless of the method used to form the grooves, ensure that the grooves are relatively smooth and uniform, and are formed without excessive tearing of the surface and without bringing pieces of the coarse aggregate to the top of the surface.

If the equipment breaks down or experiences mechanical failure, the Contractor may use manual tools for grooving, provided all mixing and placing operations cease until proper repairs are made.

Correct, at no expense to the Department, all individual areas of 50 square yards or larger of the hardened grooved concrete that do not conform to these requirements, by cutting acceptable grooves in the hardened surface with an approved cutting machine or by other approved methods.

H. Edging at Forms and Joints

After the final finish, but while the concrete is still in a plastic state, round the outside edges of the pavement to a 3/4-inch radius. When pavement is formed along a lane line, round the edges to a 1/4-inch radius. Round the edges of the pavement on each side of transverse expansion joints, formed joints, and transverse construction joints to a 1/4-inch radius. Perform edging with an approved edging tool that will produce a well-defined and continuous radius. Eliminate all tool marks formed by the edging tool by brushing to form a texture similar to the burlap drag finish.

501.17 Surface Testing, Pay Factors and Corrective Action

All surface testing and any required corrective work shall be performed as soon as practicable and before sealing joints and opening to traffic.

A. Surface Testing

As soon as the concrete has hardened sufficiently, the Department will test the pavement surface with a 12-foot straightedge. When the straightedge is placed parallel to the centerline of the pavement, the surface deviation from the lower edge of the straightedge shall not exceed 1/8 inch for mainline and auxiliary lanes and 1/4 inch for ramps.

In addition to the straightedge test, Rainhart Profilograph tests or Roadway Profiler tests of the pavement surface using a 0.1-inch blanking band will be performed on the following pavements:

1. Mainline pavement

2. Auxiliary lanes

3. Ramp sections where the design speed is greater than 40 miles per hour.

   (a) Test sections shall terminate 100 feet from a stop or slow speed yield condition

   (b) Test sections shall terminate at the beginning of a superelevation transition into a section not meeting the greater than 40-miles per hour criteria

B. Pay Factors and Required Corrective Action

Payment factors and required corrective actions relative to profile indexes for mainline roadways, auxiliary lanes and high speed ramps shall conform to Table 501.17-1.

Table 501.17-1: Pay Factors & Corrective Action for Mainline Roadways, Auxiliary Lanes, and High Speed Ramps

Profile Indexes	Pay Factor	Corrective Action
<5 inch per mile	105%	None
5 to 9 inch per mile	100%	None
>9 to <12 inches per mile	98%	Grind to 9 inches per mile
12 plus inches per mile	93%	Grind to 9 inches per mile

Payment factors and required corrective actions relative to profile indexes for ramps with posted speeds of 40 MPH or less shall conform to Table 501.17-2.

Table 501.17-2: Pay Factors & Corrective Action for Ramps with Posted Speeds of 40 mph

Profile Indexes	Pay Factor	Corrective Action
<10 inches per mile	105%	None
10 to < 20 inches per mile	100%	None
20 to < 23 inches per mile	98%	Grind to 20 inches per mile
23 plus inches per mile	95%	Grind to 20 inches per mile

Consider high speed ramps between freeways that do not have stop or yield conditions to be mainline pavement.

When the pavement being constructed longitudinally abuts an adjacent pavement constructed under a previous contract, the Department will test the adjacent pavement for smoothness. If the profile index of the existing pavement surface exceeds the above limits, the Department will increase the allowable profile index of the pavement surface being constructed by half the difference between the profile index of the existing pavement surface and the requirements specified in the tables above.

To determine pavement sections where corrective work or pay adjustments will be necessary, the Department will evaluate the pavement in 0.1-mile sections. Correct all areas represented by high points having deviations in excess of 0.4 inch in 25 feet or less and all sections having a Profile Index greater than the threshold for Corrective Action in Tables 501.17-1 and 501.17-2.

After corrective action is complete, the Department will retest and evaluate the pavement.

Perform required corrective work with approved grinding equipment or by removing and replacing the pavement as directed by the Engineer. Any area or section removed shall be no less than 10 feet in length and no less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, also remove and replace all remaining portions of the slab adjacent to the joints that are less than

10 feet in length. Perform all corrective work at no cost to the Department.

After the Contractor performs corrective grinding, the Department will test the affected pavement for thickness in accordance with **501.24**.

Establish positive means to remove grinding and grooving residue. Remove solid residue from pavement surfaces before it gets blown by traffic action or wind. Do not allow residue to flow across lanes used by public traffic or into gutters or drainage facilities. Dispose of residue in a manner that will prevent residue, whether in solid or slurry form, from reaching any waterway in a concentrated state.

The Contractor may allow residue to continuously discharge on adjacent roadway slopes or ditches if the Engineer determines that there is sufficient vegetative cover to adequately filter the residue. However, if the Engineer determines that there is not sufficient vegetative cover on the adjacent roadway slopes and ditches to adequately filter the residue, then collect the residue in approved storage tanks and deposit in settling basins, spread over flat vegetated areas, or filter by other means approved by the Engineer.

501.18 Curing

Immediately after completing the finishing operations and as soon as marring of the concrete will not occur, cover and cure the entire surface of the newly placed concrete.

Where curing requires the use of water, ensure that sufficient water is available. Failure to provide a sufficient quantity of one of the curing materials specified in **913**, or lack of water for wet-curing methods, shall be cause for immediate suspension of concreting operations. Do not leave the concrete exposed for more than 30 minutes between stages of curing or during the curing period.

Perform curing according to one of the following methods:

A. Cotton or Burlap Mats

Entirely cover the surface of the pavement with cotton or burlap mats. The mats used shall be of such length (or width) that, as laid, they will extend at least twice the thickness of the pavement beyond the edges of the slab. Place the mats so that the entire surface and both edges of the

slab are completely covered. Thoroughly saturate the mats with water prior to placement. Place and weight down the mats to ensure that they remain in intimate contact with the surface covered. Keep the covering fully saturated and in place for 72 hours after the concrete has been placed unless otherwise specified.

B. Waterproof Paper

Entirely cover the top surface and sides of the pavement with waterproof paper. Lap the units at least 18 inches. Place and weight down the paper to ensure it will remain in intimate contact with the surface covered. The paper shall have such dimensions that each unit as laid will extend beyond the edges of the slab at least twice the thickness of the pavement, or it shall be of pavement width with 3-foot strips of paper provided for the edges. If laid longitudinally, cement together paper not manufactured in sizes that provide this width in such a manner that the joints do not open up or separate during the curing period. Unless otherwise specified, keep the covering in place for 72 hours after the concrete has been placed. Thoroughly wet the surface of the pavement before placing the paper.

C. Impervious Membrane Method

Spray the entire pavement surface and edges uniformly with white pigmented curing compound immediately after finishing the surface and before concrete set has taken place, or, if the pavement is cured initially with jute or cotton mats, apply the curing compound upon removal of the mats. Do not apply curing compound during rainfall.

Apply curing compound under pressure by mechanical sprayers at the rate recommended by the manufacturer. Use spraying equipment of the fully atomizing type equipped with a tank agitator. At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. During application, stir the compound continuously by effective mechanical means. The Contractor may hand spray odd widths or shapes and concrete surfaces exposed by the removal of forms. Do not apply curing compound to the inside faces of joints to be sealed. Should the film become damaged from any cause within a 72-hour curing period, repair the damaged portions immediately with additional compound.

Upon removal of side forms, immediately protect the sides of the slabs exposed by applying curing treatment equal to that provided for the surface.

D. White Polyethylene Sheeting

Entirely cover the top surface and sides of the pavement with polyethylene sheeting. Lap the units at least 18 inches. Place and weight down the sheeting to ensure it remains in intimate contact with the surface covered. Use sheeting with such dimensions that each unit as laid will extend beyond the edges of the slab at least twice the thickness of the pavement. Thoroughly wet the surface of the pavement before placing the sheeting. Unless otherwise specified, keep the covering in place for 72 hours after the concrete has been placed.

E. Curing in Cold Weather

When placing concrete in conditions where the air temperature is expected to drop below 35 °F, provide a sufficient supply of straw, hay, grass, or other suitable blanketing material along the work. At any time the temperature is expected to reach the freezing point during the day or night, spread such material over the pavement to a sufficient depth to prevent freezing of the concrete. Take care so as not to mar the concrete surface. Maintain such protection for not less than 5 days.

The Contractor is responsible for the quality and strength of concrete laid during cold weather. The Department reserves the right to require the Contractor to core the concrete to check for damage caused by freezing temperatures. Remove and replace concrete damaged by freezing action at no cost to the Department.

501.19 Removing Forms

The Contractor may remove forms once removal will not cause damage to the slab edges. Remove the forms carefully to avoid damaging the pavement. After the forms have been removed, cure the sides of the slab using one of the methods specified in **501.18**. The Engineer will consider honeycombed areas to be defective work. Remove and replace all unsound material with satisfactory material at no cost to the Department.

501.20 Sealing Joints

Seal joints with one of the specified joint sealing materials before opening the pavement to traffic and as soon after completion of the curing period as is feasible. Select the sealant from the Department's QPL, and apply it in strict accordance with the manufacturer's recommendations. Immediately before sealing, thoroughly clean each joint of all foreign material, including membrane curing compound, by sand-blasting. Subject all joints to high-pressure air blowing prior to sealing. Ensure that the joint faces are clean and dry when applying the seal. Apply the sealant to the joint immediately after cleaning.

Apply the sealing material to each joint opening to conform to the details shown on the Plans or as directed by the Engineer. Perform sealing so as not to spill material on the exposed surface of the concrete. Immediately remove any excess material on the surface of the concrete pavement, and clean the pavement surface.

Remove sealing material that does not bond to the concrete, and re-clean and reseal the joint at no expense to the Department.

Ream all random cracks with a suitable tool and fill with an approved joint sealant.

501.21 Protection of Pavement

Protect the pavement and its appurtenances against both public traffic and traffic caused by the Contractor's employees and agents. This shall include watchmen to direct traffic and the erection and maintenance of the warning signs, lights, pavement bridges, or cross-overs.

Repair or replace all damage to the pavement prior to final acceptance at no cost to the Department.

Protect all concrete paving against the effects of rain before the concrete is sufficiently hardened; have available at all times materials to protect the edges and surface of plastic concrete. Such protective materials shall include standard metal forms or wood plank having a nominal thickness of not less than 2 inches and a nominal width of not less than the thickness of the pavement at its edge for the protection of the pavement edges, and covering material such as burlap or cotton mats, curing paper, or plastic sheeting material for the protection of the surface of the pavement. When rain appears imminent, stop all paving operations and direct all available

personnel to begin placing forms against the sides of the pavement and covering the surface of the plastic concrete with the protective covering.

501.22 Opening to Traffic

The Engineer will determine when the pavement will be opened to traffic. The Engineer will not allow traffic on the completed pavement until the concrete has attained a compressive strength of 3,000 pounds per square inch or until 14 days following concrete placement, whichever occurs first. Remove and replace concrete that fails to develop a compressive strength of 3,000 pounds per square inch within 28 days at no cost to the Department, or accept reduced payment in accordance with **501.13**. Ensure pavement is free from construction debris, rocks, and other deleterious materials before opening to traffic. All other testing of the concrete pavement for smoothness and thickness shall be complete before opening to traffic.

501.23 Shoulders

Construct, shape, and dress shoulders according to the shoulder type shown on the Plans as soon as practicable following the completion of the pavement. Shoulders shall be one of the following types:

A. Base with Flexible Surface

Perform this work as specified in the applicable sections of Part 3 – Base and Subgrade Treatments and Part 4 – Flexible Surfaces.

Construct longitudinal joints between the concrete pavement and the asphalt shoulder by sawing, unless otherwise directed by the Engineer, to form an opening 1 inch wide by 1 inch deep, as measured from the lowest elevation. Install sealant with equipment recommended by the sealant manufacturer, which is capable of maintaining a uniform, homogeneous mixture throughout the sealing operation. Apply the sealant so that it flows into the joint without overlapping onto the pavement. Remove all sealant that overlaps onto the pavement at no cost to the Department.

B. Base with Rigid Surface

Perform this work in accordance with the applicable Sections of Part 3 – Base and Subgrade Treatments and Part 5 – Rigid Pavement.

Construct the longitudinal joint between the Portland cement concrete pavement and the Portland cement concrete shoulder in accordance with these Specifications and the details shown on the Plans. Use materials, including tie bars and joint sealant, that are of the same type as the Portland cement concrete mainline pavement.

Construct transverse joints in the Portland cement concrete shoulder to correspond to the transverse joints in the Portland cement concrete roadway and to be of the same type, material, and spacing. Both expansion and contraction joints shall include dowel assemblies of the same type specified for the roadway pavement.

501.24 Tolerance in Pavement Thickness

The Department will determine pavement thickness based on the average measurement of cores taken by the Contractor from each unit as defined in **501.24.A**. The Department will calculate the average thickness of each unit and determine the associated payment for the area represented in accordance with **501.24.B**.

A. Defining Units

For the purpose of determining the pavement thickness and for establishing an adjusted unit price for pavement that is deficient in thickness, the Department will define separate units as follows, unless otherwise specified:

1. Placement widths of 1,000 feet in length, starting at the end of the pavement bearing the smaller station number, will be considered separate units. The placement width is the width of a separately placed lane or lanes.

2. Last units having a length between 500 feet and 1,000 feet will be treated as separate units. The Department will include last units having a length not exceeding 500 feet in the last full unit.

3. Units on interchange ramps will be considered separately from units on the main line.

4. Each intersection will be considered as one unit.

5. Crossovers, entrances, and similar small areas may be combined to form a unit of 1,000 square yards or less. In each unit so established, the Department will make thickness measurements and apply price adjustments, if any, as specified in **501.24.B,** for pavement units on the main line and ramps, except the location and spacing of cores will be as designated by the Engineer.

B. Average Thickness Measurements and Payment Adjustments

Take core samples at locations determined and witnessed by a Department representative and documented on the appropriate form.

When the measurement of the core from a unit is within 1/4 inch from the Plan thickness, the Department will make full payment for the pavement in the area represented.

When such measurement is deficient by more than 1/4 inch but not more than 1 inch from the Plan thickness, the Department will direct two additional cores to be taken from within the unit at intervals of not less than 300 feet, and will determine the average of the three cores. If the average measurement of these three cores is within 1/4 inch of the Plan thickness, the Department will make full payment. If the average thickness of the three cores is deficient by more than 1/4 inch but not more than 1 inch from the Plan thickness, the Department will pay an adjusted price, determined in accordance with **501.26.B**, for the area represented by these cores.

In calculating the average thickness of the pavement unit, the Department will consider measurements that exceed the average thickness by more than 1/4 inch as the specified thickness plus 1/4 inch, and will exclude from the average measurements that are less than the specified thickness by more than 1 inch.

When the measurement of any core is less than the specified thickness by more than 1 inch, the Department will determine the actual thickness of the pavement in this area from additional cores taken at not less than 10-foot intervals parallel to the centerline in each direction from the affected location until a core is found, in each direction, that is not deficient by more than 1 inch. The Engineer will evaluate areas found deficient in thickness by more than 1 inch, and if, in the Engineer's judgment, the deficient areas warrant removal, the Contractor shall remove and replace them, at no additional cost to the

Department, with concrete of the thickness shown on the Plans. The Department will not include exploratory cores for areas deficient by more than 1 inch in thickness when determining averages for adjusted unit prices.

COMPENSATION

501.25 Method of Measurement

The Department will measure Portland Cement Concrete Pavement (Plain) and Portland Cement Concrete Pavement (Reinforced) of the various thicknesses specified, by the square yard in accordance with **109**.

The Department will measure additional concrete required to level individual ramps, including acceleration and deceleration lanes, containing 4,500 square yards or less, by the cubic yard. Where a ramp becomes a traffic lane without a tapered acceleration lane, or a traffic lane becomes a ramp without a tapered deceleration lane, the Department will consider 300 feet of the lane, measured from the point of intersection with the adjoining lanes, as an acceleration or deceleration lane to be included in the ramp. To determine the number of cubic yards of additional concrete, the Department will deduct the theoretical quantity and all wasted concrete from the number of cubic yards actually used, as determined from invoices or conversion from batch weights.

The Department will not measure for payment additional concrete used for leveling on main line roadway or ramps that contain more than 4,500 square yards.

501.26 Basis of Payment

A. General

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Portland Cement Concrete Pavement (Plain) ___"	Square Yard
Portland Cement Concrete Pavement (Reinforced) __"	Square Yard
Portland Cement Concrete Shoulders	Square Yard

Such payment is full compensation for furnishing all materials including reinforcing, dowels, and joint material.

Payment for Portland Cement Concrete Pavement, of the type and thickness shown on the Plans, also includes all labor, equipment, materials, and incidentals required to construct the longitudinal joint between the pavement and either flexible or rigid shoulders, and to texture the surface by forming transverse grooves.

Payment for Portland Cement Concrete Shoulders, of the type and thickness shown on the Plans, includes all labor, equipment, materials, and incidentals required to construct transverse joints in the Portland cement concrete shoulders.

For pavement found deficient in thickness by more than 1/4 inch but not more than 1 inch, the Department will pay only the reduced price specified in **501.26.B**. No additional payment over the contract unit bid price will be made for pavement that has an average thickness in excess of that shown on the Plans.

The Department will pay for additional concrete used for leveling on ramps that contain 4,500 square yards or less based on the invoice price of the concrete when the concrete is purchased from a ready-mix producer. If the concrete is mixed on the Project by the Contractor, the price per cubic yard will be based on the invoice price of the materials plus 20%. The Department will make payment only on that portion of additional concrete that exceeds 4% of the theoretical quantity; no payment will be made for additional concrete exceeding 10% of the theoretical quantity.

The Department will pay for additional concrete, measured in accordance with **501.25**, at the purchase price, F.O.B. the unloading point, as verified by invoices, with no compensation allowed for further handling. The State will be reimbursed from monies due the Contractor for a decrease in concrete measured in accordance with **501.25** in an amount equal to the purchase price of the cement, F.O.B. the unloading point. No payment will be allowed for any changes in the proportions of the aggregates.

B. Price Adjustments

1. **Pavement Thickness.** Where the average thickness per unit of pavement is deficient in thickness by more than 1/4 inch, but not

more than 1 inch, the Department will pay an adjusted price as specified in Table 501.26-1.

Table 501.26-1: Price Adjustment for Concrete Pavement Deficiency

Deficiency in Thickness Determined by Cores (Inches)	Proportion of Contract Price Allowed
0 through 0.25	100%
0.26 through 0.50	75%
0.51 through 0.75	60%
0.76 through 1.00	50%

When the thickness of pavement is deficient by more than 1 inch and the judgment of the Engineer is that the area of such deficiency does not warrant removal and the Contractor elects not to remove the pavement, there will be no payment for the area retained.

2. Pavement Rideability. The Department will adjust the unit price paid for Portland Cement Concrete Pavement in accordance with the tables in **501.17**.

If the pavement being tested abuts an adjacent pavement constructed under a previous contract, the profile indexes in Tables 501.17-1 and 501.17-2 will be adjusted as described in **501.17** for the corresponding Pay Factors.

The adjusted unit price will apply to the total area of the 0.1 mile-section for the lane width represented by the road profiler or profilograph.

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DESCRIPTION

601.01 Description

This work consists of constructing structures or parts of structures, other than piling, composed of timber, treated or untreated, or a combination of both, on prepared foundations at the locations shown on the Plans or as directed by the Engineer.

Construct those parts of timber structures to be constructed with materials other than timber, such as concrete and steel, as specified in the Sections pertaining to the respective types of structure.

MATERIALS

601.02 Materials

Provide materials as specified in:

Timber **911**

Provide timber of the dimensions shown on the Plans. The dimensions on the Plans are intended to represent the commercial product.

Untreated timber used for mud sills shall be heart cedar, heart cypress, redwood, or other durable timber.

Obtain the Engineer's approval of the design of ring or shear plate timber connectors. Provide connectors of galvanized metal meeting the appropriate ASTM standard.

Provide hardware for timber structures of the design, size, kind, and composition shown on the Plans or as directed by the Engineer.

601.03 Reserved

CONSTRUCTION REQUIREMENTS

601.04 Preliminary Work

Perform Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, Structure Excavation, Foundation Preparation and Backfill, and Embankment Construction as specified in **201**, **202**, **203**, **204**, and **205**, respectively.

601.05 Care and Protection of Timber

Handle all timber with care, and store upon platforms, skids, or other supports at least 12 inches above the ground surface. Stack and strip timber to allow for the free circulation of air between the tiers and courses. Cover the stacked timber. Clear the ground underneath and in the vicinity of the timber of all weeds, rubbish, and other objectionable material, and shape to allow surface water flow to drain away from the stockpiled material.

601.06 Components of Timber Structures

A. Mud Sills

Firmly and evenly bed mud sills to a solid bearing, and tamp in place.

B. Concrete Pedestals

Finish concrete pedestals for the support of framed bents so that the sills or posts will receive an even and uniform bearing. Slope the tops of pedestals projecting outside the bearing area downward to direct water away from the bearings. Set dowels, of not less than 3/4 inches in diameter and projecting the proper distance above the tops of the pedestals, 9 inches in the pedestal when they are being cast.

C. Sills

Secure sills with 3/4-inch diameter drift bolts extending into the mud sills, piles, or pedestals at least 9 inches. When possible, remove all earth from contact with sills to provide free circulation of air around the sills.

D. Caps

Set caps as shown on the Plans, and so as to have full and even bearing on piles or other supports in the bent, and to provide even bearing and full contact with the stringers placed on the caps. Secure caps to each pile or post by a 3/4-inch drift bolt placed approximately at the center of the pile or post, and extending through the cap and at least 9 inches into the pile or post. Secure caps to other supports as shown on the Plans.

E. Posts for Bents

Fasten posts to sills and pedestals with dowels of not less than 3/4 inches in diameter extending into posts and sills as shown on the Plans.

F. Framing

Cut and frame truss and bent timbers to a close fit in such manner that they will have an even bearing over the entire contact surface of the joint. Do not perform any blocking or shimming when making joints. The Engineer will reject open joints.

Ensure that mortises are true to size for their full depth, and tenons make a snug fit therein. Mortises and tenons shall be draw-bored.

G. Stringers

Set and place all stringers to the required elevations so as to give flooring an even bearing at all contacts or intersections.

Size stringers at bearings and place in position so that knots near edges will be in the top portion of the stringer.

Unless otherwise specified, outside stringers shall have butt joints, but frame interior stringers to bear over the full width of floor beam or cap at each end of the stringer.

Separate the ends of untreated stringers at least 1/2 inch to allow for air circulation, and securely fasten the ends to the timber upon which they rest.

Ensure that cross-bridging between stringers is neatly and accurately framed and securely toe-nailed with at least two nails in each end.

H. Flooring

Construct all flooring as shown on the Plans or as directed by the Engineer. Ensure that flooring has even, full, and uniform free bearing on each and all stringers, and is not pulled or warped to have such bearing. Only use shims and wedges with the Engineer's approval. When constructing timber flooring, take care to place flooring pieces of the same thickness adjacent to each other.

I. Wheel Guards

Construct wheel guards on each side of the roadway as shown on the Plans. Place the wheel guards in sections not less than 12 feet in length, unless otherwise shown on the Plans or directed by the Engineer.

Unless otherwise indicated, fasten wheel guards with 5/8-inch bolts not to exceed 5-foot 3-inch centers. Fasten the ends of all wheel guards sections. The bolts shall extend entirely through the riser blocks and floor plank.

J. Railing

Unless otherwise indicated or directed, provide railings of untreated, dressed lumber, constructed in a workmanlike and substantial manner. Construct the railings as shown on the Plans and to be reasonably true to line and grade. Paint the railings.

K. Bore Holes

Bore holes as follows:

1. **Round Bolts, Spikes, and Dowels.** Use a bit 1/16 inch less in diameter than the bolt, spike, or dowel to be used. The diameter of the holes for square bolts, spikes, or dowels shall be equal to the least dimension of the bolt or dowel.

2. **Machine Bolts.** Use a bit of the same diameter as the bolt.

3. **Rods.** Use a bit 1/16 inch greater in diameter than the rod.

4. **Screws.** Use a bit slightly smaller than the body of the screw at the base of the thread, but not to the full depth of the screw.

Re-treat all bolt holes bored after treatment with an approved treatment. Plug unfilled holes, after being treated, with treated plugs.

L. Bolts, Nuts, and Washers

Provide bolts, nuts, and washers of the kinds and sizes specified. Bolts shall have square heads and nuts. All bolts shall be galvanized. Vertical bolts shall have the nuts on the lower end.

Use a washer under the head or nut of all bolts or lag screws coming in contact with timber. Washers shall be of the same character as the bolt or screw with which they are used.

M. Countersinking

Countersink nuts and bolt heads as directed by the Engineer. Fill the recesses formed by countersinking with hot tar pitch.

N. Spiking

When using spikes to spike one member to another, with spikes 7 inches or longer as shown on the Plans, or when necessary in erection, drill holes through the member 1/16 inch less than the diameter of the spike that is to be driven. Drive spikes to the depth required to embed the full thickness of the head into the timber.

601.07 Erection

In erecting timber structures, or parts of structures, allow for the typical variations in Plans dimensions from commercial dimensions of timber so as to obtain the required finished elevations and finished dimensions of the structure, without the use of shims or blocks.

Position and fasten timbers as shown on the Plans or as directed by the Engineer.

Perform all construction in a workmanlike manner, and ensure that the structure presents a neat finish and appearance when completed.

Place planks with the heart side down, with 1/4-inch openings between planks, unless otherwise shown on the Plans or directed by the Engineer. Fasten planks at each intersection to a nail strip or joist with two wire spikes of the size indicated or directed.

In structures constructed in whole or in part of treated timber, thoroughly coat with an approved treatment all areas, where the timber surface is broken after treatment. Completely fill holes in treated timber caused by withdrawing bolts, nails, spikes, or other causes with an approved treatment.

In structures constructed in whole or in part of untreated timber, thoroughly treat, as specified above, heads of piles not encased in concrete, ends, tops, and all contact surfaces of truss members, laterals, and braces, before assembling.

Thoroughly coat, as specified above, the back face of bulkheads and all other parts of timber in contact with earth.

For timber surfaces that are to be painted in the completed structure, paint those portions coming in contact with other timber or material before being fastened or placed, as specified for railings in **601.08**.

Remove and replace, at no cost to the Department, all damaged or unsatisfactory timber.

601.08 Paint and Painting

Paint railings, except those or parts of those constructed of treated timber, with three coats of paint applied as specified in **603.** Comply with the type, sequence, and colors shown on the Plans.

Paint all metals, unless otherwise shown or directed, as specified in **603**.

601.09 Final Cleanup

When finishing a structure, clean exposed timber of any discoloration caused by the construction operations.

Store all material becoming the property of the Department as directed by the Engineer.

Perform final cleanup as specified in **104.10**.

COMPENSATION

601.10 Method of Measurement

The Department will measure Untreated Timber and Treated Timber, complete in place and accepted, by the 1,000 board foot measure (MBFM) in accordance with **109**.

The Department will consider hardware used in a structure to be incidental to the Untreated Timber and Treated Timber bid items.

601.11 Basis of Payment

The Department will pay for accepted quantities of timber structures at the contract prices as follows:

Item	*Pay Unit*
Treated Timber	MBFM
Untreated Timber	MBFM

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DESCRIPTION

602.01 Description

This work consists of furnishing the various materials for the fabrication, erection, and painting of bridges and such other parts of bridges that are composed of structural steel and miscellaneous metals, except steel piling or metal reinforcement for concrete.

MATERIALS

602.02 Materials

Provide materials as specified in:

Structural Steel and Appurtenant Materials **908**

Paint **910**

For materials not covered by these Specifications, comply with the AASHTO Bridge Specifications identified on the Plans. Refer to the Plans for testing requirements and dimensions of materials.

602.03 Reserved

CONSTRUCTION REQUIREMENTS – FABRICATION

602.04 Shop Inspection

A. AISC Certification for Steel Fabricators

Fabricators of steel bridges shall hold the following certifications in accordance with the AISC Certification Program for Structural Steel Fabricators – Standard for Steel Bridges:

1. As a minimum, all fabricators shall be certified in the category of intermediate bridges with applicable supplemental requirements.

2. Fabricators of advanced type bridges, as defined in the AISC Standard for Steel Bridges, shall be certified in the category of advanced bridges with applicable supplemental requirements.

3. Fabricators of diaphragms, cross-frames, floor beams, stringers (rolled beams) and laterals shall be certified in the category of Intermediate bridges, as a minimum.

4. Fabricators of bridge bearings, expansion joints, sign structures and other metal highway components as listed in the AISC standard shall hold certification under the AISC Certification Program - Standard for Bridge and Highway Metal Component Manufacturers. As an alternative, fabricators of bridge bearing or expansion joints may hold certification in the category of Intermediate bridges under the Standard for Steel Bridges.

B. Quality Assurance (QA) Shop Inspection

At least 6 weeks before starting shop fabrication, provide written notification to the Division of Structures, with a copy to the Engineer, as to the location and schedule of the fabrication of structural steel, so that the Department may arrange for QA shop inspection.

The Department will pay for the cost of this QA inspection, limited to the rates set forth in the Special Provisions for each weight range.

To establish the maximum inspection cost to be paid by the Department, the Department will multiply the per pound inspection cost for each specified weight range by the applicable steel poundage within its weight range. The Department will deduct the cost of all structural steel inspection (QA) in excess of this maximum cost from monies due the Contractor. The cost for structural steel inspection (QA) includes the cost of an inspection agency hired by the Department to perform shop inspection (QA) of steel fabrication. The Contractor may obtain a detailed description of the duties of an inspection agency from the Engineer.

The shop inspection performed by the inspection agency hired by the Department is intended as QA to assure to the Department that the fabricator is following all quality control requirements and is providing a product conforming to the Contract requirements. The inspection agency is not instructed or expected to replace the fabricator's quality control. The inspection and acceptance of the work performed by the Department's inspection agency does not relieve the fabricator of providing materials and finished products as specified. The Department may reject defective or non-conforming materials at any time. Replace rejected materials promptly at no additional cost to the Department.

Include the cost of nondestructive testing in the lump sum bid price for steel structures.

602.05 General

A. Type of Construction

The type of construction shall be welded or bolted, as shown on the Plans.

B. Workmanship and Finish

Workmanship and finish shall be in accordance with the American Institute of Steel Construction (AISC) best general practices in modern bridge shops. Provide a neat finish to portions of the work exposed to view.

C. Storage of Materials

Store material, either plain or fabricated, above the ground on platforms, skids, or other supports. Keep materials free from dirt, grease, or other foreign matter, and provide appropriate protection from corrosion.

D. Straightening Material

Ensure that rolled material, before being laid off or worked, is straight. If straightening is necessary, use methods that will not damage the metal.

Only perform heat straightening of ASTM A709, Grade 100W, 244 (ASTM A514) or ASTM A517 steel under rigidly controlled procedures, with each application subject to the Engineer's approval. Do not allow the maximum temperature of the steel to exceed 1100 °F as set forth in the AASHTO *Guide Specifications for Highway Bridge Fabrication with High Performance Steel*, current edition, and the AASHTO *Bridge Welding Code*, current edition. The Engineer will reject material with sharp kinks and bends.

To straighten plates, angles, other shapes, and built-up members when permitted by the Engineer, use methods that will not fracture or otherwise damage the metal.

Straighten distorted members by mechanical means or, if approved by the Engineer, by carefully planned procedures and supervised application of a limited amount of localized heat. However, to heat straighten AASHTO M 270 (ASTM A709) Grades HPS70W and 100W steel members, adhere to the AASHTO *Guide Specification for Highway Bridge Fabrication with High Performance Steel*, current edition, and the AASHTO *Bridge Welding Code*, current edition, with each application subject to the Engineer's approval. Do not exceed the maximum temperatures specified in Table 602.05-1.

Table 602.05-1: Heat Straightening

Grade	Maximum Temperature, degrees F
Grade HPS70W > 6 inches from weld	1100 °F
Grade HPS70W < 6 inches from weld	900 °F
Grade 100W > 6 inches from weld	1100 °F
Grade 100W < 6 inches from weld	950 °F

In all other steels, do not allow the temperature of the heated area to exceed 1200 °F, as controlled by temperature indicating crayons, liquids, or either contact or non-contact infrared thermometers. Heating in excess of the limits shown will be cause for rejection, unless the Engineer allows testing to verify material integrity.

Keep parts to be heat straightened substantially free of stress and from external forces, except stresses resulting from mechanical means used in conjunction with the application of heat.

The Engineer will reject pieces showing evidence of fracture following straightening of a bend or buckle.

E. Heat Curving Rolled Beams and Welded Girders

1. Materials. Do not perform heat-curving in steels that are manufactured to a specified minimum yield point greater than 70,000 pounds per square inch.

2. Type of Heating. Curve beams and girders by either continuous or V-type heating as approved by the Engineer.

a. Continuous Method. For the continuous method, heat a strip along the edge of the top and bottom flanges simultaneously. Ensure that the strip is of sufficient width and temperature to obtain the required curvature.

b. V-type Heating. For V-type heating, heat the top and bottom flanges at approximately the same rate and in regularly spaced truncated triangular or wedge-shaped areas having their base along the flange edge. Determine the spacing and temperature of areas necessary to obtain the required curvature. On the inside flange surface, terminate the apex of the truncated triangular area just before the juncture of the web and the flange. To avoid web distortion, take special care when heating the inside flange surfaces (the surfaces that intersect the web) so that heat is not applied directly to the web. When the radius of curvature is 1,000 feet or more, extend the apex of the truncated triangular heating pattern applied to the outside flange surface to the juncture of the flange and web. When the radius of curvature is less than 1,000 feet, extend the apex of the truncated triangular heating pattern applied to the outside flange surface past the web for a distance equal to 1/8 of the flange or 3 inches, whichever is less. The truncated triangular pattern shall have an included angle of approximately 15 to 30 degrees and a base of no greater than 10 inches. The Engineer may approve variations in these patterns.

For both types of heating, the flange edges 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 only required when the flange thickness is 1-1/4 inches or greater, in which case, heat the two surfaces concurrently.

3. Temperature. Conduct the heat-curving operation so that the temperature of the steel does not exceed 1200 °F for Grades 36, 50, 50W, and HPS50W; and 1100 °F for Grades HPS70W and 100W, as measured by temperature-indicating crayons or other suitable means. Do not artificially cool the girder until after it has naturally cooled to 600 °F; the method of artificial cooling is subject to the Engineer's approval.

4. Position for Heating. The girder may be heat-curved with the web in either a vertical or a horizontal position.

When curving girders with the web in the vertical position, brace or support the girder to prevent it from overturning.

When curving with the web in the horizontal position, support the girder near its ends and at intermediate points, if required, to obtain uniform curvature. Do not allow the bending stress in the flanges due to the dead weight of the girder and externally applied loads to exceed the usual allowable design stress. During heating, maintain intermediate safety catch blocks at the mid-length of the girder within 2 inches of the flanges to avoid a sudden sag due to plastic flange buckling.

5. **Sequence of Operations.** Heat-curve the girder before painting, and either before or after completing all the required welding of transverse intermediate stiffeners. However, unless provisions are made for girder shrinkage, locate and attach connection plates and bearing stiffeners after heat curving. If longitudinal stiffeners are required, heat-curve or oxygen-cut them separately, and then weld them to the curved girder. When attaching cover plates to rolled beams, attach them before heat curving if the total thickness of one flange and cover plate is less than 2-1/2 inches and the radius of curvature is greater than 1,000 feet. For other rolled beams with cover plates, heat-curve the beams before attaching the cover plates. Either heat-curve or oxygen-cut cover plates separately, and then weld them to the curved beam.

6. **Camber.** Camber girders before heat curving. Camber rolled beams by heat-cambering methods approved by the Engineer. For plate girders, cut the web to the prescribed camber with suitable allowance for shrinkage due to cutting, welding, and heat curving. If necessary, correct moderate deviations from specified camber by a carefully supervised application of heat, as approved by the Engineer.

7. **Measurement of Curvature and Camber.** The Engineer will measure horizontal curvature and vertical camber for final acceptance after all welding and heating operations are completed and the flanges have cooled to a uniform temperature. The Engineer will check horizontal curvature with the girder in the vertical position.

8. Finish. Provide a neat finish to exposed portions of the work. Perform shearing, flame cutting, and chipping carefully and accurately.

602.06 Bolt Holes

A. Holes for High Strength Bolts and Unfinished Bolts[1]

Punch or drill all bolt holes. Material forming parts of a member composed of not more than five thicknesses of metal may be punched 1/16 inch larger than the nominal diameter of the bolts where the thickness of the material is not greater than 3/4 inch for structural steel, 5/8 inch for high-strength steel, or 1/2 inch for quenched and tempered alloy steel, unless sub-punching and reaming is required under **602.09**.

Where there are more than five thicknesses, or when any of the main material is thicker than 3/4 inch for structural steel, 5/8 inch for high-strength steel, or 1/2 inch for quenched and tempered alloy steel, either sub-drill and ream or drill holes full size.

If required under **602.09**, either sub-punch or sub-drill (sub-drill if thickness limitation governs) all holes 3/16 inch smaller, and, after assembling, ream 1/16 inch larger, or drill full size to 1/16 inch larger than the nominal diameter of the bolts.

The Department will only allow use of enlarged or slotted holes with high-strength bolts 5/8 inch or larger in diameter where shown on the design drawings.

B. Holes for Ribbed Bolts, Turned Bolts or other Approved Bearing Type Bolts

The Fabricator may either sub-punch or sub-drill all holes for ribbed bolts, turned bolts, or other approved bearing-type bolts 3/16 inches smaller than the nominal diameter of the bolt, and then ream, assemble or drill to a steel template or, after assembly, drill from the solid. In any case, ensure that the finished holes provide a driving fit as shown on the Plans or specified in the Special Provisions.

[1] See **602.16** for bolts included in designation "Unfinished Bolts."

602.07 Punched Holes

Use a die diameter that is not more than 1/16 inch larger than the punch diameter. Ream holes that must be enlarged to admit bolts. Ensure that holes are cleanly cut without torn or ragged edges. Poor matching of holes will be cause for rejection.

602.08 Reamed or Drilled Holes

Ream or drill holes so they are cylindrical and perpendicular to the member and sized to comply with **602.06**. Where practicable, direct reamers using mechanical means. Remove burrs on the outside surfaces. Poor matching of holes will be cause for rejection. Ream and drill holes with twist drills. If required by the Engineer, take apart assembled pieces to remove burrs caused by drilling. Assemble and securely hold together connecting parts that are being reamed or drilled and match-mark before disassembling.

602.09 Preparation of Field Connections

A. Sub-punching and Reaming of Field Connections

Unless otherwise specified in the Special Provisions or shown on the Plans, sub-punch (or sub-drill if sub-drilling is required) the holes in all field connections and field splices of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, and rigid frames, as specified in **602.06**, and subsequently ream while assembled or to a steel template, as specified in **602.13**. Sub-punch all holes for floor beam and stringer field connections, and ream to a steel template or while assembled.

When reaming or drilling full size field connection holes through a steel template, accurately locate and position the template and firmly bolt in place before drilling. Ensure that templates used for reaming matching members, or the opposite faces of a single member, are exact duplicates. Accurately locate templates used for connections on like parts or members so that the parts or members are duplicates and require no match-marking.

For any connection, instead of sub-punching and reaming or sub-drilling and reaming, the Fabricator may drill holes full size with all thicknesses of material assembled in proper position.

The Special Provisions or the Plans will identify if any additional sub-punching and reaming is required.

B. Numerically Controlled (N/C) Drilled Field Connections

1. General. For any connection or splice specified in **602.09.A**, instead of drilling undersized holes and reaming while assembled, or drilling holes full size while assembled, the Contractor may use N/C drilling equipment to drill bolt holes full-size in unassembled pieces and/or connections including templates for use with matching undersized and reamed holes.

If N/C drilling equipment is used, the Engineer, unless otherwise stated in the Special Provisions or shown on the Plans, may require the Contractor, by means of check assemblies, to demonstrate that this drilling procedure consistently produces holes and connections meeting **602.11** and **602.13**. Submit to the Engineer for approval a detailed outline of the proposed procedures for accomplishing the work, from initial drilling through check assembly, if required. Identify in the submittal the specific members of the structure that may be N/C drilled, the sizes of the holes, the location of common index and other reference points, composition of check assemblies, and all other pertinent information.

2. Holes. Ensure that holes drilled by N/C drilling equipment are drilled to appropriate size either through individual pieces or any combination of pieces held tightly together.

602.10 Accuracy of Punched and Drilled Holes

Punch holes so that, after assembling (before any reaming is done), a cylindrical pin 1/8 inch smaller in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member, without drifting, in at least 75% of the contiguous holes in the same plane. The Engineer will reject pieces that do not meet this requirement. The Engineer will also reject all holes that will not pass a pin 3/16 inch smaller in diameter than the nominal size of the punched holes.

602.11 Accuracy of Reamed and Drilled Holes

When holes are reamed or drilled, 85% of the holes in any contiguous group shall, after reaming or drilling, show no offset greater than 1/32 inch between adjacent thicknesses of metal. Use steel templates having

hardened steel bushings in holes accurately dimensioned from the center lines of the connection as inscribed on the template. Use the center lines when locating the templates from the milled or scribed ends of members.

602.12 Fitting for Bolting

Clean surfaces of metal in contact before assembling. Before reaming, ensure that the parts of a member are assembled, well pinned, and firmly drawn together with bolts. When necessary, take assembled pieces apart to remove burrs and shavings produced by the reaming operation. Ensure that members are free from twists, bends, and other deformation.

602.13 Shop Assembling

Assemble the field connections of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, and rigid frames in the shop with milled ends of compression members in full bearing, and then ream their sub-size holes to the specified size while the connections are assembled. Assembly may be full truss or girder assembly, progressive truss or girder assembly, full chord assembly, progressive chord assembly, or special complete structure assembly unless otherwise specified in the Special Provisions or shown on the Plans.

Fabricate check assemblies with numerically controlled (N/C) drilled field connections as specified in **602.13.F**.

Obtain the Engineer's approval of each assembly, including camber, alignment, accuracy of holes, and fit of milled joints, before starting reaming or before dismantling an N/C drilled check assembly.

The Fabricator shall submit to the Engineer a camber diagram showing the camber at each panel point for trusses or arch ribs and at the location of field splices and fractions of span length (1/4 points minimum, 1/20 points maximum) for continuous beam and girders or rigid frames. When the shop assembly is Full Truss or Girder Assembly or Special Complete Structure Assembly, the camber diagram shall show the camber measured in assembly. For the other shop assembly methods, the camber diagram shall show calculated camber.

A. Full Truss or Girder Assembly

Full Truss or Girder Assembly shall consist of assembling all members of each truss, arch rib, bent, tower face, continuous beam line, plate girder, or rigid frame at one time.

B. Progressive Truss or Girder Assembly

Progressive Truss or Girder Assembly shall consist of assembling initially for each truss, arch rib, bent, tower face, continuous beam line, plate girder, or rigid frame at least three contiguous shop sections or all members in at least three contiguous panels but not less than the number of panels associated with three contiguous chord lengths (i.e., length between field splices) and not less than 150 feet in the case of structures longer than 150 feet. Add at least one shop section or panel or as many panels as are associated with a chord length at the advancing end of the assembly before removing any member from the rearward end, so that the assembled portion of the structure is never less than that specified above.

C. Full Chord Assembly

Full Chord Assembly shall consist of assembling, with geometric angles at the joints, the full length of each chord of each truss or open spandrel arch, or each leg of each bent or tower, then reaming their field connection holes while the members are assembled and reaming the web member connections to steel templates set at geometric (not cambered) angular relation to the chord lines.

Ream field connection holes in web members to steel templates. Ensure that at least one end of each web member is milled or scribed normal to the longitudinal axis of the member. Accurately locate the templates at both ends of the member from one of the milled ends or scribed lines.

D. Progressive Chord Assembly

Progressive Chord Assembly shall consist of assembling contiguous chord members in the manner specified for Full Chord Assembly in **602.13.C** and in the number and length specified for Progressive Truss or Girder Assembly in **602.13.B**.

E. Special Complete Structure Assembly

Special Complete Structure Assembly shall consist of assembling the entire structure, including the floor system. (This procedure is ordinarily needed only for complicated structures such as those having curved girders or extreme skew in combination with severe grade or camber.)

F. Check Assemblies with Numerically Controlled (N/C) Drilled Field Connections

Fabricate a check assembly for each major structural type of each project, unless otherwise shown on the Plans or specified in the Special Provisions. The check assembly shall consist of at least three contiguous shop sections or, for a truss, all members in at least three contiguous panels but not less than the number of panels associated with three contiguous chord lengths (i.e., length between field splices). Base check assemblies on the proposed order of erection, joints in bearings, special complex points (such as portals of skewed trusses), and similar considerations.

Use geometric angles (giving theoretically zero secondary stresses under dead load conditions after erection) or cambered angles (giving theoretically zero secondary stresses under no load conditions) as shown on the Plans or specified in the Special Provisions.

For each major structural type to be fabricated, fabricate the check assemblies first. The Department does not require any matchmaking or shop assemblies other than the check assemblies.

If the check assembly fails to demonstrate that the required accuracy is being obtained, the Engineer may require the fabrication of additional check assemblies at no cost to the Department.

602.14 Drifting of Holes

Only drift holes during assembling to the extent that it brings the parts into position, but does not enlarge the holes or distort the metal.

602.15 Match-Marking

Match-mark connecting parts preassembled in the shop to ensure proper fit in the field. Provide a diagram showing such match-marks to the Engineer.

602.16 Bolts and Bolted Connections

The requirements of this Subsection do not pertain to the use of high strength bolts. For bolted connections fabricated with high strength bolts, comply with **602.17**.

A. General

Use unfinished, turned, or ribbed bolts conforming to ASTM A307 for Grade A bolts for Low-Carbon Steel Externally and Internally Threaded Standard Fasteners. Only use bolted connections as shown on the Plans or specified in the Special Provisions. Use bolts with single self-locking nuts or double nuts unless otherwise shown on the Plans or specified in the Special Provisions. Use beveled washers where bearing faces have a slope of more than 1:20 with respect to a plane normal to the bolt axis.

B. Unfinished Bolts

Furnish unfinished bolts unless other types are specified.

C. Turned Bolts

Furnish turned bolts having a body surface that meets the ANSI roughness rating value of 125. Furnish hex headed bolts and nuts of the nominal size specified or the next larger nominal size. The thread diameter shall be equal to the body of the bolt or the nominal diameter of the bolt specified. Carefully ream holes for turned bolts with bolts furnished to provide for a light driving fit. Keep bolt threads entirely outside of the holes. Provide a washer under the nut.

D. Ribbed Bolts

The body of ribbed bolts shall be of an approved form with continuous longitudinal ribs. The diameter of the body measured on a circle through the points of the ribs shall be 5/64 inch greater than the nominal diameter specified for the bolts.

Furnish ribbed bolts with round heads conforming to ANSI B 18.5 unless otherwise specified. Furnish hexagonal nuts that are either recessed or have a washer of suitable thickness. Ribbed bolts shall have a driving fit when installed in the holes. The hardness of the ribs shall be such that the ribs do not compress, deform, or allow the bolts

to turn in the holes during tightening. If the bolt twists before drawing tight, ream the hole and provide an oversized replacement bolt.

602.17 Connections Using High Strength Bolts

A. General

This Subsection covers the assembly of structural joints using AASHTO M 164 (ASTM A325) or ASTM A490 high strength bolts, or equivalent fasteners, tightened to a high tension. Use the bolts in holes conforming to **602.06**, **602.07**, and **602.08**.

B. Bolts, Nuts, and Washers

The Department will pre-test bolts, nuts, and washers in accordance with **908.04**. Bolts used with weathering steel shall be ASTM A325 Type 3, and all bolts, nuts and washers shall have the same weathering characteristics as the structural steel. Galvanized nuts shall be grade DH. Supply the Materials and Tests Division with samples of bolts, nuts, and washers used on the Project for purposes of testing (provide three per shipping lot).

Where the outer face of the bolted parts has a slope greater than 1:20 with respect to a plane normal to the bolt axis, use a hardened beveled washer to compensate for the lack of parallelism.

Use hardened beveled washers for American Standard Beams and Channels. The washers shall be square or rectangular, shall conform to the requirements of AASHTO M 293 (ASTM F436) and AASHTO M 253, and shall taper in thickness.

Where necessary, washers may be clipped on one side from the center of the washer to a point not closer than 7/8 times the bolt diameter.

Hardened washers are not required for connections using AASHTO M 164 (ASTM A325) and AASHTO M 253 (ASTM A490) bolts except as follows:

1. Use hardened washers under the turned element when tensioning is to be performed by the calibrated wrench method.

2. Regardless of the tensioning method, use hardened washers under both the head and the nut when ASTM A490 bolts are to be installed in material having a specified yield point less than 40 kips per square inch. However, use of DTI's may replace a hardened washer provided a standard hole is used.

3. Where AASHTO M 164 (ASTM A325) bolts of any diameter or ASTM A490 bolts equal to or less than 1 inch in diameter are to be installed in oversize or short-slotted holes in an outer ply, use a hardened washer conforming to AASHTO M 293 (ASTM F436).

4. Where ASTM A490 bolts over 1 inch in diameter are to be installed in an oversized or short-slotted hole in an outer ply, use a hardened washer conforming to AASHTO M 293 (ASTM F436).

5. Where ASTM A490 bolts over 1 inch in diameter are to be installed in an oversized or short-slotted hole in an outer ply, use hardened washers conforming to AASHTO M 293 (ASTM F436) except with 5/16 inch minimum thickness under both the head and the nut instead of standard thickness hardened washers. Using multiple hardened washers with a combined thickness equal to or greater than 5/16 inch does not satisfy this requirement.

6. Where AASHTO M 164 (ASTM A325) bolts of any diameter or ASTM A490 bolts equal to or less than 1 inch in diameter are to be installed in a long slotted hole in an outer ply, use a plate washer or continuous bar of at least 5/16 inch thickness with standard holes. The washers or bars shall have a size sufficient to completely cover the slot after installation and shall be of structural grade material, but need not be hardened except as follows. When ASTM A490 bolts over 1 inch in diameter are to be used in long slotted holes in external plies, use a single hardened washer conforming to AASHTO M 293 (ASTM F436), but with 5/16 inch minimum thickness, instead of washers or bars of structural grade material. Using multiple hardened washers with combined thickness equal to or greater than 5/16 inch does not satisfy this requirement.

7. Alternate design fasteners conforming to Article 11.3.2.6, with a geometry that provides a bearing circle on the head or nut

with a diameter equal to or greater than the diameter of hardened washers conforming to AASHTO M 293 (ASTM F436), satisfy the requirements for washers specified herein and may be used without washers.

C. Bolted Parts

Limit the maximum slope of surfaces of bolted parts in contact with the bolt head and nut to 1:20 with respect to a plane normal to the bolt axis. Ensure that bolted parts fit solidly together when assembled and are not separated by gaskets or any other interposed compressible material.

Ensure that, when assembled, all joint surfaces, including those adjacent to the bolt head, nuts or washers, are free of loose scale, burrs, dirt, and other foreign material that would prevent solid seating of the parts. Paint is permitted unconditionally in bearing type connections.

Unless otherwise shown on the Plans, all contact surfaces of bolted parts shall be Class B as described in the AASHTO Bridge Specifications identified in the Plans.

D. Installation

Comply with the following when installing high strength bolts in the field or shop:

1. Install bolts to the minimum tensions specified in Table 602.17-1 and in accordance with the AASHTO LRFD Bridge Construction Specifications identified on the Plans. During installation, take particular care so as to achieve the snug tight condition as defined in Article 11.5.6.4.

Table 602.17-1: Minimum Bolt Tension [1]

Bolt Diameter (inches)	Bolt Tension (pounds)	
	AASHTO M 164 Bolts (ASTM A325)	ASTM A490 Bolts
1/2	12,000	15,000
5/8	19,000	24,000
3/4	28,000	35,000
7/8	39,000	49,000
1	51,000	64,000
1-1/8	56,000	80,000
1-1/4	71,000	102,000
1-3/8	85,000	121,000
1-1/2	103,000	148,000

[1] Equal to 70% of the specified minimum tensile strength of bolts.

2. Perform the rotational capacity test described in **602.17.E.1** and **602.17.E.2** on each rotational capacity lot before starting bolt installation. Provide hardened steel washers as part of the test.

3. Install bolt, nut, and washer combinations of the same rotational capacity lot together.

4. Un-galvanized bolts shall be "oily" to the touch when delivered and installed.

5. Clean and re-lubricate weathered or rusted bolts or nuts not satisfying the requirements of paragraph D.2 above prior to installation. Test re-cleaned or re-lubricated bolt, nut, and washer assemblies in accordance with paragraph D.2 above prior to installation.

6. Direct Tension Indicators (DTIs)

    a. Use Direct Tension Indicators (DTIs) for each bolt. Do not use DTIs on weathering steel, and therefore all bolts shall be installed by either turn-of-nut tightening or

calibrated wrench tightening in accordance with the construction specifications of the AASHTO Bridge Specifications identified on the Plans. The load indicator average gap shall be 0.005 inch. After the joint has been properly pinned, tighten the joint to approximately half the specified tension to ensure firm contact of all plies, and then tighten the joint by systematically progressing from the center most rigid part to the free edges. Re-tightening may be necessary to restore tension if gaps increase from original measurements.

b. Maintain a tension calibrator, such as a Skidmore Wilhelm, on the Project during all bolting operations. The Engineer will check the bolt tension versus the average gap of the DTI daily to ensure correct tension.

c. Supply the Materials and Tests Division with samples of bolts, nuts, and washers used on the project for purposes of testing (provide three per shipping lot).

d. Ship bolts, nuts, and washers in sealed containers, labeled with the supplier's name and lot identification. Ensure that the containers are capable of protecting the bolts from moisture and other contaminants until they are opened at the site. Damaged containers are cause for rejection.

e. Verify the DTI's performance as specified in **602.17.E.3**.

f. Install DTIs by one of the following three methods unless otherwise approved by the Engineer.

(1) Place the DTI under the bolt head and turn the nut to tighten. The protrusions on the DTI shall face the underside of the bolt head. Place the hardened flat washer under the nut and reduce the gap in the DTI to 0.005 inch.

(2) Place the DTI under the nut and turn the nut to tighten. Place the hardened flat washer between the nut and the DTI. The protrusions on the DTI shall face the underside of the hardened flat washer and nut and the gap in the DTI reduced to 0.005 inch. This method is suggested when it is too difficult to

see the bolt head for inspection, or when the wrench operator wants to the see the gap.

(3) Place the DTI under the bolt head and turn the bolt head to tighten. Place the hardened flat washer between the bolt head and the DTI. The protrusions on the DTI shall face the underside of the hardened flat washer and bolt head and the gap in the DTI reduced to 0.005 inch. This method is suggested when it is too difficult to see the nut for inspection, or when the wrench operator wants to the see the gap.

E. Inspection

In the presence of the Engineer, conduct the following tests to certify materials in accordance with **908.04** and prior to installation:

1. Rotational Capacity Tests on Long Bolts in Tension Calibrator

a. Equipment Required

1. Calibrated bolt tension measuring device of size required for bolts to be tested. Mark off a vertical line and lines 1/3 of a turn (120 degrees); and 2/3 of a turn (240 degrees), from vertical in a clockwise direction on the face plate of the calibrator.

2. Calibrated torque wrench.

3. Spacers and/or washers with hole size no larger than 1/16 inch greater than bolt to be tested.

4. Steel section to mount bolt calibrator. Flange of girder or cross frame accessible from the ground is satisfactory.

b. Procedure

1. Install nut on bolt and measure stick-out of bolt when three to five full threads of the bolt are located between the bearing face of the nut and the bolt head.

Measure the bolt length, the distance from the end of the threaded shank to the underside of the bolt head.

2. Install the bolt into the tension calibrator and install the required number of shim plates and/or washer (one washer under the nut must always be used) to produce the thread stick-out measured in Step 1.

3. Tighten bolt using a hand wrench to the snug tensions specified in Table 602.17-2, -0 kips, +2 kips.

Table 602.17-2: Snug Tension

Bolt Diameter (inches)	Snug Tension (kips)
1/2	1
5/8	2
3/4	3
7/8	4
1	5
1-1/8	6
1-1/4	7
1-3/8	9
1-1/2	10

4. Match mark the nut to the vertical stripe on the face plate of the bolt calibrator.

5. Using the calibrated manual torque wrench, tighten the bolt to at least the tension specified in Table 602.17-3, and record the torque required to reach the tension and the value of the bolt tension. Measure torque with the nut in motion.

Table 602.17-3: Minimum Installation Tension

Bolt Diameter (inches)	Tension (kips)
1/2	12
5/8	19
3/4	28
7/8	39
1	51
1-1/8	56
1-1/4	71
1-3/8	85
1-1/2	103

6. Further tighten the bolt to the rotation specified in Table 602.17-4. Measure the rotation from the initial marking in Step 4. Record the bolt tension. Assemblies that fail prior to this rotation either by stripping or fracture fail the test.

Table 602.17-4: Rotation from Snug Condition

Bolt Length (measured in Step 1)	Required Rotation
Up to and including 4 diameters	2/3
Over 4 diameters, but not exceeding 8 diameters	1
Over 8 diameters	1-1/3

7. The bolt tension measured in Step 6 after the required rotation must equal or exceed the values specified in Table 601.17-5. Assemblies that do not meet this tension have failed the test.

Table 602.17-5: Turn Test Tension

Bolt Diameter (inches)	Tension (kips)
1/2	14
5/8	22
3/4	32
7/8	45
1	59
1-1/8	64
1-1/4	82
1-3/8	98
1-1/2	118

8. Loosen and remove the nut and examine the threads on the nut and bolt. No signs of thread shear failure, stripping, or torsional failure of the bolt should be evident. Assemblies that have evidence of stripping have failed the test.

9. Ensure that the torque measured in Step 5 does not exceed the maximum torque calculated as follows:

$$T_{max} = 0.25\ (P \times 1{,}000)\left(\frac{D}{12}\right)$$

Where:

T_{max}	=	maximum torque expressed in foot-pounds
P	=	bolt tension measured in Step 5 expressed in kips
D	=	bolt diameter expressed in inches

Assemblies with torque values exceeding this calculated value have failed the test.

2. Rotational Capacity Tests on Bolts too Short to fit Tension Calibrator

a. Equipment Required

1. Calibrated torque wrench and a spud wrench or equivalent.

2. Spacers and/or washers with hole size no larger than 1/16 inch greater than bolt to be tested.

3. Steel section with normal size hole to install bolt. Any available splice hole can be used with a plate thickness that will provide the number of threads under the nut required in Step 1 below. Mark off a vertical line and lines 1/3 of a turn (120 degrees); 1/2 of a turn (180 degrees); and 2/3 of a turn (240 degrees), from vertical in a clockwise direction on the plate.

b. Procedure

1. Install nut on bolt and measure stick-out of bolt when three to five full threads of the bolt are located between the bearing face of the nut and the bolt head. Measure the bolt length, the distance from the end of the threaded shank to the underside of the bolt head.

2. Install the bolt into the hole and install the required number of shim plates and/or washer (one washer under the nut must always be used) to produce the thread stick-out measured in Step 1.

3. Use a hand wrench to tighten the bolt to a snug condition. The snug condition is the normal effort applied to a 12 inch long wrench. The applied torque should not exceed 20% of the torque determined in Step 5.

4. Match mark the nut to the vertical stripe on the plate.

5. Tighten the bolt by turning the nut using the torque wrench to the rotation specified in Table 602.17-6.

Use a second wrench to prevent rotation of the bolt head during tightening. Record the torque required to reach this rotation. Measure torque with the nut in motion.

Table 602.17-6

Bolt Length (measured in Step 1)	Required Rotation
Up to and including 4 diameters	1/3
Over 4 diameters, but not exceeding 8 diameters	1/2
Over 8 diameters, but not exceeding 12 diameters	2/3

The measured torque should not exceed the values specified in Table 602.17-7. Assemblies that exceed the listed torques have failed the test.

Table 602.17-7

Bolt Diameter (inches)	Torque (ft-lbs)
1/2	150
5/8	290
3/4	500
7/8	820
1	1,230
1-1/8	1,500
1-1/4	2,140
1-3/8	2,810
1-1/2	3,690

6. Tighten the bolt further to the rotation specified in Table 602.17-8. The rotation is measured from the initial marking in Step 4. Assemblies that fail prior to this rotation either by stripping or fracture have failed the test.

Table 602.17-8

Bolt Length (measured in Step 1)	Required Rotation
Up to and including 4 diameters	2/3
Over 4 diameters, but not exceeding 8 diameters	1
Over 8 diameters, but not exceeding 12 diameters	1-1/3

7. Loosen and remove the nut and examine the thread on the nut and bolt. No signs of thread shear failure, stripping, or torsional failure of the bolt should be evident. Assemblies that have evidence of stripping have failed the test.

3. Verification and Installation of High Strength Bolts with Direct Tension Indicators (DTIs)

a. Verification of DTI Performance. If installing DTIs with high strength bolts to indicate bolt tension, perform the verification testing described below, and install the DTIs in accordance with the method specified below. Unless otherwise approved by the Engineer, install the DTIs under the head of the bolt and turn the nut to tighten the fastener. Follow the manufacturer's recommendations to properly orient the DTI and additional washers, if any, required for the correct use of the DTI.

In the presence of the Engineer, perform verification testing in a calibrated bolt tension measuring device. Use a special flat insert in place of the normal bolt head holding insert. Perform three verification tests for each combination of fastener rotational-capacity lot, DTI lot, and DTI position relative to the turned element (bolt head or nut) to be used on the project. Tighten the fastener by turning the element not against the DTI. Do not allow the element (bolt head or nut) against the DTI to rotate. The purpose of the verification testing is to ensure that the fastener will be at or above the desired installation tension when half or more of the spaces in the DTI have a gap of less than 0.005 inch and that the fastener will

not undergo excessive plastic deformation at the minimum gap allowed on the Project.

Conduct the verification test as follows:

1. Install the bolt, nut, and DTI assembly in a manner so that at least three and preferably not more than five threads are located between the bearing face of the nut and the bolt head.

2. Tighten the fastener first to the load equal to that specified in Tables 602.17-9 and 602.17-10 under Verification Tension for the grade and diameter of fastener. If an impact wrench is used, it is acceptable to tighten to a load slightly below that required and then use a manual wrench to attain the required tension.

3. Determine and record the number of refusals of a 0.005-inch tapered feeler gage in the spaces between the protrusions. The number of spaces between protrusions is listed below in Tables 602.17-9 and 602.17-10. The number of refusals shall not exceed the number listed under Maximum Verification Refusals in Tables 602.17-9 and 602.17-10 below for the grade and diameter of bolt for un-coated DTIs. The maximum number of refusals for coated DTIs (galvanized, painted or epoxy coated) used under the turned element shall not exceed the number of spaces on the DTI less one. The DTI lot is rejected if the number of refusals exceeds the values in the applicable table or, for coated DTIs, if the gage is refused in all spaces.

4. After the number of refusals is recorded at the verification load, further tighten the fastener until the 0.005-inch feeler gage is refused at all the spaces and a visible gap exists in at least one space.

5. Record the load at this condition and remove the fastener from the tension measuring device.

6. Ensure that the nut can be reassembled by hand for the complete thread length of the bolt excluding thread run-out. If the nut cannot be assembled for this thread length, the DTI lot is rejected unless the load recorded is less than 95% of the average load measured in the rotational capacity test of the fastener lot as specified in **908.04.C.3.g**.

If the bolt is too short to be tested in the calibration device, test the DTI on a long bolt in a calibrator to determine the number of refusals at the Verification Tension listed in Tables 602.17-9 and 602.17-10 below. The number of refusals shall not exceed the values listed under Maximum Verification Refusals. Then test another DTI from the same lot with the short bolt in a convenient hole in the work. Tighten the fastener assembly until the 0.005-inch feeler gage is refused in all spaces and a visible gap exists in at least one space. Disassemble the fastener. Ensure that the nut can be reassembled by hand for the complete thread length of the bolt excluding thread run-out. Reject the DTI lot if the nut cannot be assembled to this thread length.

b. Installation. Install fasteners using DTIs in two stages. Prevent rotation of the fastener element during each stage of the installation.

1. First, snug the connection with bolts installed in all the holes of the connection. Then, tighten the bolts sufficiently to bring all the plies of the connection into firm contact. Ensure that the number of spaces in which a 0.005 inch-feeler gage is refused in the DTI after snug does not exceed those listed under Maximum Verification Refusals in Tables 602.17-9 and 602.17-910 for the grade and diameter of bolt. If the numbers exceed the values in the table, remove the fastener, install another DTI, and re-snug the fastener.

2. Further tighten the connection until the number of refusals of the 0.005-inch feeler gage is equal to or greater than the number listed under Minimum Installation Refusals in Tables 602.17-9 and 602.17-10 for the grade and diameter of bolt. If the

fastener is tightened so that no visible gap in any space remains, remove the bolt and DTI, and replace with a new properly tightened fastener and DTI.

Table 602.17-9: DTI Requirements for A325 Bolts

Bolt Diameter (inches)	Verification Tension (kips)	Maximum Verification Refusals	DTI Spaces	Minimum Installation Refusals
1/2	13	1	4	2
5/8	20	1	4	2
3/4	29	2	5	3
7/8	41	2	5	3
1	54	2	6	3
1-1/8	59	2	6	3
1-1/4	75	3	7	4
1-3/8	89	3	7	4
1-1/2	108	3	8	4

Table 602.17-9: DTI Requirements for A490 Bolts

Bolt Diameter (inches)	Verification Tension (kips)	Maximum Verification Refusals	DTI Spaces	Minimum Installation Refusals
1/2	16	2	5	3
5/8	25	2	5	3
3/4	37	2	6	3
7/8	51	2	6	3
1	67	3	7	4
1-1/8	84	3	7	4
1-1/4	107	3	8	4
1-3/8	127	3	8	4
1-1/2	155	4	9	5

c. Equipment Required

1. Calibrated bolt tension measuring device with a special flat insert in place of normal bolt head holding insert. Special insert required to allow access to measure DTI gap.

2. Tapered leaf thickness (feeler) gage 0.005 inch. Same gage as to be used to inspect the bolts after installation.

3. Bolts, nuts, and standard washers to be used in the work with the DTIs.

4. Impact and manual wrench to tighten bolts. Equipment should be the same as to be used in the work.

d. Verification Test Procedure. Conduct three tests for each rotational-capacity lot and position of DTI.

1. Install bolt, nut, DTI, and standard washer (if used) into bolt tension measuring device. Assembly should match that to be used in the work.

2. Snug the bolt to no more than 50% of the required installation tension using the equipment that will be used in the work. Use another wrench on the bolt head to prevent rotation of the head against the DTI if the DTI is to be used under the unturned element.

3. Further tighten the bolt to tension specified in Table 602.17-11 (which is 1.05 times the required installation tension of the bolt). Use another wrench on the bolt head to prevent rotation of the head against the DTI if the DTI is to be used under the unturned element. If an impact wrench is used, tighten to a load slightly below the required load and use a manual wrench to attain the required tension. The load indicating needle of the bolt calibrator cannot be read accurately when an impact wrench is used.

Table 602.17-11

Bolt Diameter (inches)	Bolt Tension (kips)	
	AASHTO M 164 Bolts (ASTM A325)	ASTM A490 Bolts
1/2	13	N/A
5/8	20	N/A
3/4	29	37
7/8	41	51
1	54	67
1-1/8	59	84
1-1/4	75	107
1-3/8	89	127
1-1/2	108	N/A

4. Determine and record the number of spaces between the protrusions on the DTI that a 0.005-inch thickness gage is refused. The total number of spaces in the various sizes and grade of DTIs is listed in Table 602.17-12.

Table 602.17-12

Bolt Diameter (inches)	Number of Spaces	
	AASHTO M 164 Bolts (ASTM A325)	ASTM A490 Bolts
1/2	4	N/A
5/8	4	N/A
3/4	5	6
7/8	5	6
1	6	7
1-1/8	6	7
1-1/4	7	8
1-3/8	7	8
1-1/2	8	N/A

5. The number of spaces that the 0.005-inch thickness gage is refused should not exceed the number specified in Table 602.17-13. If the number of spaces exceeds the number in the table, the DTI fails the verification test.

Table 602.17-13: Verification Criteria [(1)]

Number of Spaces in Washer	Maximum Number of Spaces Gage is Refused
4	1
5	2
6	2
7	3
8	3

(1) If the test is a coated DTI under the turned element, the maximum number of spaces the gage is refused is the number of spaces on the washer minus one.

6. Further tighten the bolt to the smallest gap to be allowed in the work. Normally, this smallest gap is defined as the gap at all the spaces less than 0.005 inch and not all gaps completely closed. Ensure that the 0.005-inch gage is refused at all spaces, but a visible gap exists in at least one space. The bolts in this test and in the actual installation should not be installed to a no visible gap condition. The load in the bolt becomes indeterminate when no gap exists. Failure of the bolt due to over-tightening may occur if the bolt is tightened beyond complete crushing of the DTI.

7. Remove the bolt from the calibrator and turn the nut on the threads of the bolt by hand. The nut should be able to be turned on the complete length of the threads, excluding the thread run-out. If the nut is unable to go the full thread length, the load required for the minimum gap in Step 6 is too large. The test must be repeated with a larger minimum gap, for example, one space that will accept a 0.005-inch feeler gage to establish the smallest gap allowed in the work for the fastener rotational-capacity lot allowed in the work.

8. Bolts from rotational-capacity lots that are too short to fit in the tension measuring device shall be tested by tightening to the minimum gap in Step 6 and checked in accordance with Step 7. The DTI used with the short bolt should be checked in accordance with Steps 1 through 5 using a longer bolt in the tension measuring device.

602.18 Plate Cut Edges

A. Edge Planing

Remove to a depth of 1/4 inch all sheared edges of plates that are thicker than 5/8 inch and carry calculated stress. Fillet re-entrant corners to a minimum radius of 3/4 inch before cutting.

B. Visual Inspection and Repair of Plate Cut Edges

Visually inspect and repair plate cut edges in accordance with Article 3.2.3 of the AASHTO/AWS *Bridge Welding Code*, D1.5, current edition.

602.19 Welds

Perform all welding in accordance with the AASHTO/AWS *Bridge Welding Code*, D1.5, current edition. Where conflicts occur, these Specifications shall govern.

Grind all full penetration welds in webs and flanges flush with the base metal.

The following are revisions to the AASHTO/AWS *Bridge Welding Code*:

1. Add the following sentence to Article 6.1.1.1:

   After fabrication, Quality Control (QC) shall mark each piece (girders, beams, diaphragms, X-frames, bearings, etc.) with the fabricators logo and the CWI Number of the QC Inspector accepting the piece. These stamps will signify that Quality Control (QC) has inspected the piece and that it meets the requirements of the plans and specifications.

2. Delete Article 6.1.3.1(3).

3. Delete Article 6.1.3.2.

4. Delete the last sentence in Article 6.1.3.4 and substitute the following:

   Only individuals certified for NDT Level II may perform nondestructive testing.

5. Delete 6.1.3.4(1) and 6.1.3.4(2).

6. Delete the period at the end of Article 6.6.1 and add the following:

   and access to all records necessary to verify conformance to plans and specifications.

7. Delete Article 6.7.1 and substitute the following:

   Complete joint penetration groove welds in main members, as identified in the contract documents shall be QC tested by nondestructive testing.

   Radiographic and ultrasonic testing shall both be performed in accordance with the requirements of Section 6.7.1.2:

8. Delete 6.7.1.2(2d) and substitute the following:

   Longitudinal butt joints in beam or girder webs shall be 100% QC tested by nondestructive testing.

9. Add the following Article 6.17.5:

   Each Ultrasonic Unit shall be certified for general operational performance at a minimum time interval of 12 months with a method approved by the instrument manufacturer.

602.20 Facing of Bearing Surfaces

Finish bearing and base plates and other bearing surfaces that will come in contact with each other or with concrete according to the ANSI surface roughness requirements defined in ANSI B46.1, *Surface Roughness, Waviness and Lay, Part I*, as specified in Table 602.20-1.

Table 602.20-1: Surface Roughness

Bearing Surface	ANSI Roughness Value
Steel Slabs	2000
Heavy plates in contact in shoes to be welded	1000
Milled ends of compression members, milled or round ends of stiffeners and fillers	500
Bridge rollers and rockers	250
Pins and pin holes	125
Sliding bearings	125

602.21 Abutting Joints

Face and bring abutting joints to an even bearing in compression members and girder flanges, and in tension members where so shown on the Plans and show working drawings. Where joints are not faced, the opening shall not exceed 1/4 inch.

602.22 End Connection Angles

Build floor-beams, stringers, and girders having end connection angles to the exact length shown on the Plans, as measured between the heels of the connection angles, with a permissible tolerance of plus 0 inch to minus 1/16 inch. Where continuity is required, face end connections. The thickness of the connection angles shall not be less than 3/8 inch or less than that shown on the detail drawings, after facing.

602.23 Lacing Bars

Neatly round the ends of lacing bars unless another form is required.

602.24 Fabrication of Members

Unless otherwise shown on the Plans, cut and fabricate steel plates for main members and splice plates for flanges and main tension members, not secondary members, so that the primary direction of rolling is parallel to the direction of the main tensile and/or compressive stresses.

Ensure that fabricated members are true to line and free from twists, bends and open joints.

602.25 Web Plates

In built-up girders having no cover plates and that will not be encased in concrete, the top edge of the web plate shall not extend above the backs of the flange angles and shall not be more than 1/8 inch below at any point. Chip portions of the plate, projecting beyond the angles, flush with the backs of the angles. Web plates of girders having cover plates may be 1/2 inch less in width than the distance back to back of flange angles. Before painting, use silicone caulk to seal the top of splices of webs in girders without cover plates.

At web splices, the clearance between the ends of the web plates shall not exceed 3/8 inch. The clearance at the top and bottom ends of the web splice plates shall not exceed 3/4 inch.

602.26 Bent Plates

Furnish un-welded, cold bent, load carrying, rolled steel plates conforming to the following:

1. Take material from the stock plates so that the bend line will be at right angles to the direction of rolling, except that cold-bent ribs for orthotropic deck bridges may be bent in the direction of rolling if approved by the Engineer.

2. Before bending, round the corners of the plate to a radius of 1/16 inch throughout the portion of the plate where bending is to occur.

3. Cold bend so that no cracking of the plate occurs. Use the minimum bend radii, shown in Table 602.26-1, measured to the concave face of the metal.

Table 602.26-1: Minimum Cold-Bending Radii

Thickness (inches) [1,2]	Minimum Bending Radii (by Steel Grade)					
	36	**50**	**50W**	**HPS70W**	**100**	**100W**
$t \leq 3/4$	1.5t	1.5t	1.5t	1.5t	1.75t	1.75t
$3/4 < t \leq 1$	1.5t	1.5t	1.5t	1.5t	2.25t	2.25t
$1 < t \leq 2$	1.5t	2.0t	2.0t	2.5t	4.5t	4.5t
$t > 2$	2.0t	2.5t	2.5t	3.0t	5.5t	5.5t

(1) t = plate thickness

(2) Low alloy steel in thickness over 1/2 inch may require hot bending for small radii.

Allow for spring-back of ASTM A709 Grade 100 or 100W steels equal to about 3 times that for structural carbon steel. For break press forming, use a lower die span of at least 16 times the plate thickness. Multiple hits are advisable.

If a radius shorter than the minimum specified for cold bending is essential, hot bend the plates at a temperature not greater than 1200 °F, except for ASTM A709 Grade HPS70W steels. If ASTM A709 Grade HPS70W steel plates to be bent are heated to a temperature greater than 1100 °F, re-quench and temper according to the producing mill's standard practice. Hot bent plates shall conform to requirement (1) above.

602.27 Fit of Stiffeners

Fabricate (by milling, grinding, or welding, as shown on the Plans or otherwise specified) end-bearing stiffeners of girders and stiffeners intended as supports for concentrated loads to provide full bearing on the flanges to which they transmit load or from which they receive load. Stiffeners not intended to support concentrated loads shall, unless shown or specified otherwise, fit sufficiently tight to exclude water after being painted. Fillers under stiffeners shall fit within 1/4 inch at each end.

602.28 Eyebars

Pin holes may be flame cut at least 2 inches smaller in diameter than the finished pin diameter. Securely fasten together, in the order that they will

be placed on the pin, all eyebars that are to be placed side by side in the structure, and bore at both ends while so clamped. Pack and match-mark eyebars for shipment and erection. Stamp all identifying marks with steel stencils on the edge of one head of each member after fabrication is completed so as to be visible when the bars are nested in place on the structure. Ensure that the eyebars are straight and free from twists with pin holes accurately located on the centerline of the bar. The inclination of any bar to the plane of the truss shall not exceed 1/16 inch to a foot.

Simultaneously cut the edges of eyebars that lie between the transverse centerline of their pin holes with two mechanically operated torches abreast of each other, guided by a substantial template, to prevent distortion of the plates.

602.29 Annealing and Stress Relieving

Machine, finish bore, and straighten structural members, indicated in the Contract to be annealed or normalized, after heat treatment. Normalize and anneal (full annealing) according to ASTM A919. Maintain uniform temperatures throughout the furnace during the heating and cooling so that the temperature difference between any two points on the member does not exceed 100 °F at any one time.

Do not anneal or normalize members of ASTM A709 Grade 100W steels. Stress relieve these grades only with the Engineer's approval.

Maintain a record of each furnace charge, identifying the pieces in the charge and listing the temperatures and schedule actually used. Provide proper instruments, including recording pyrometers, for determining at any time the temperatures of members in the furnace. The records of the treatment operation shall be available to and meet the approval of the Engineer. The holding temperature for stress relieving ASTM A709 Grade HPS70W and 100W steels shall not exceed 1100 °F.

Stress relieve members, such as bridge shoes, pedestals, or other parts that are built up by welding sections of plate together, according to Section 4.4 of AASHTO/AWS *Bridge Welding Code* D1.5 when required by the Contract.

602.30 Pins and Rollers

Accurately fabricate pins and rollers to the dimensions shown on the Plans and working drawings and to be straight, smooth, and free from flaws.

Forge and anneal pins and rollers more than 9 inches in diameter. Pins and rollers 9 inches or less in diameter may be either forged and annealed or cold-finished carbon steel shafting.

In pins larger than 9 inches in diameter, bore a hole not less than 2 inches in diameter full length along the axis after the forging has been allowed to cool to a temperature below the critical range, under suitable conditions to prevent damage by too rapid cooling, and before being annealed.

602.31 Boring Pin Holes

Bore pin holes true to the specified diameter, smooth and straight, at right angles with the axis of the member and parallel with each other unless otherwise required. Produce the final surface using a finishing cut.

The distance outside-to-outside of end holes in tension members and inside-to-inside of end holes in compression members shall not vary from that specified more than 1/32 inch.

602.32 Pin Clearances

The diameter of the pin hole shall not exceed that of the pin by more than 1/50 inch for pins 5 inches or less in diameter or by 1/32 inch for larger pins.

602.33 Threads for Bolts and Pins

Provide threads on all bolts and pins for structural steel construction that conform to the Unified Standard Series UNC-ANSI B 1.1, Class 2A for external threads and Class 2B for internal threads; but when pin ends have a diameter of 1-3/8 inches or more, provide 6 threads to the inch.

602.34 Pilot and Driving Nuts

Provide two pilot nuts and two driving nuts for each size of pin, unless otherwise specified.

602.35 Identification of Steels During Fabrication

A. Identification by Contractor

Provide the Engineer with complete certified mill test reports showing chemical analysis and physical tests for each heat of steel for all members unless excepted by the Engineer. Properly identify for the Engineer each piece of steel to be fabricated.

Identify in the shop drawings each piece that is to be made of steel other than ASTM A709 Grade 36 steel. Ensure that pieces made of different grades of steel are not given the same assembling or erecting mark, even if they are of identical dimensions and detail.

Use a system of assembly-marking of individual pieces made of steel other than ASTM A709 Grade 36 steel and of issuing cutting instructions to the shop (generally by cross-referencing the assembly marks shown on the shop drawings with the corresponding item covered on the mill purchase order) that will maintain identity of the mill test report number.

The Contractor may furnish material from stock that can be identified by heat number and mill test report.

Mark any excess material placed in stock for later use with the mill test report number and with its AASHTO M 160 (ASTM A6) specification identification color code, if any, when separated from the full-size piece furnished by the supplier.

B. Certification of Identification

Upon request, furnish an affidavit certifying that throughout the fabrication, the identification of steel was maintained in accordance with this Specification.

602.36 Weighing of Members

If it is specified that any part of the material is to be paid for by actual weight, weigh the finished work in the presence of the Engineer, if practicable. In such case, supply satisfactory scales and perform all work involved in handling and weighing the various parts.

602.37 Full Size Tests

When the Contract requires full size tests of fabricated structural members or eyebars, the Plans or Specifications will state the number and nature of the tests, the results to be attained, and the measurements of strength, deformation or other performance parameters that are to be made. Provide suitable facilities, material, supervision, and labor necessary for making and recording the tests. The Department will pay for the testing of members in accordance with the Contract as specified in **602.50**. Include the cost of testing, including equipment, handling, supervision, labor, and incidentals for making the tests, in the Contract price for the fabrication or fabrication and erection of structural steel, whichever is the applicable item in the Contract, unless otherwise specified.

602.38 Marking and Shipping

Paint or mark each member with an erection mark for identification. Provide an erection diagram that identifies the erection marks. Permanently stencil heat numbers on the main material so they will be identifiable in the field. Ensure that the steel fabricator submits three sketches identifying these heat numbers on 8-1/2 by 11-inch sheets to the Inspecting Agency and to the Engineer (see example shown in Figure 602.38-1).

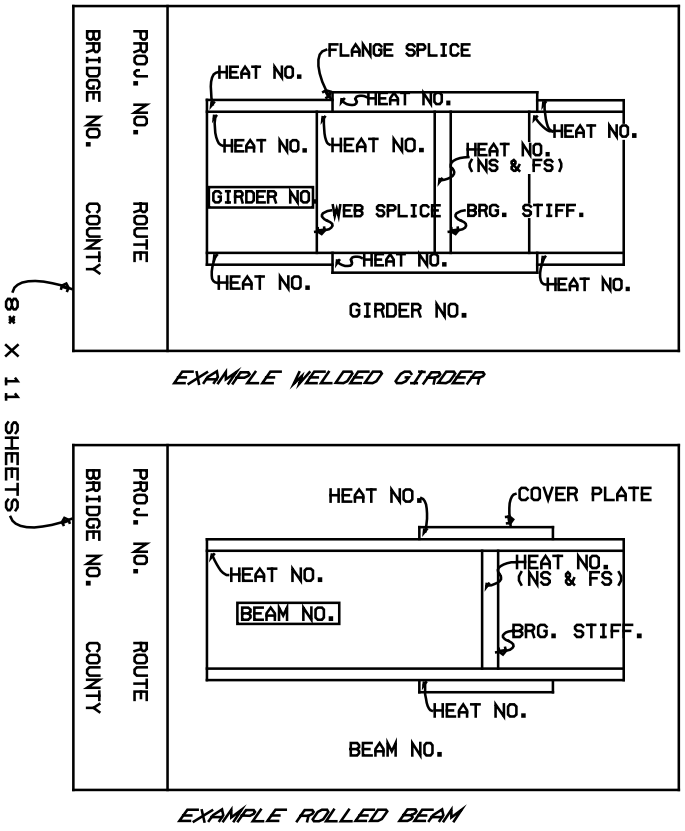


Figure 602.38-1: Example Diagrams showing Heat Numbers

In addition to the heat number shown, the fabricator shall identify all high strength steels regardless of where it is used.

Provide as many copies of material orders, shipping statements, and erection diagrams as the Engineer may direct. Identify the weights of the individual members on the statements. Mark members weighing more than 3 tons with their weights. Load structural members on trucks or cars so that they may be transported and unloaded at their destination without being excessively stressed, deformed, or otherwise damaged.

Separately pack bolts of one length and diameter and loose nuts or washers of each size. Ship pins, small parts, and packages of bolts, washers, and nuts in boxes, crates, kegs, or barrels. Ensure that the gross weight of each package does not exceed 300 pounds. Plainly mark the outside of each shipping container with a list and description of the contained material.

CONSTRUCTION REQUIREMENTS – ERECTION

602.39 Erection

Provide the falsework and all tools, machinery, and appliances, including drift-pins and fitting-up bolts, necessary for the expeditious performance of the work. Erect the metalwork, remove the temporary construction, and do all work necessary to complete the structure as required by the Contract.

A. Shear Stud Connectors

After erecting the beams, attach the shear stud connectors in compliance with OSHA standards. Install the studs in the locations shown on the Plans. Install and test shear studs in accordance with the latest version of AASHTO/AWS D1.5, Chapter 7 Stud Welding. Clean the surface receiving the studs by shot blasting or grinding to a bright metal surface immediately before welding. Weld studs using automatically timed stud welding equipment only. At the beginning of each day or shift, each individual welder/operator and equipment must complete the Production Control/Pre-production Testing described in paragraph 7.7.1 of AASHTO/AWS D1.5. Only allow individuals, who repeatedly demonstrate satisfactory installation, to install the shear studs. The Contractor is responsible for the quality of all welds.

The Department will inspect and randomly test the welds before any reinforcing steel is placed.

602.40 Handling and Storing Materials

Place material to be stored on the Project on skids above the ground. Keep material clean and properly drained. Place girders and beams upright and shore. Support long members, such as columns and chords, on skids placed near enough together to prevent damage due to deflection.

If the Contract is for erection only, check the material received against the shipping lists and report promptly in writing any shortage or damage

discovered. The Contractor is responsible for the loss of and damage to any material in its care.

602.41 Temporary Supports

Design, construct, and maintain temporary supports for steel beam erection to support the loads to which they will be subjected. Submit construction drawings for temporary supports and working drawings for changes in any existing structure necessary for safely maintaining traffic, in accordance with **105.02**. All drawings shall be stamped by a Professional Engineer licensed in the State of Tennessee.

602.42 Method and Equipment

All contractors and subcontractors directly engaged in the erection or removal of structural steel, precast prestressed or mild steel reinforced concrete bridge beams or girders over active highway traffic lanes, on any route, railroad or any stream deemed navigable to commercial or pleasure water craft, shall submit an erection plan prepared and stamped by a Professional Engineer licensed in the State of Tennessee. Include the following in this plan: the sequence of erection, the generalized location of all pick points, and the plan to adequately stabilize the structure throughout the erection process. Submit this plan to the Engineer at least 30 days before starting erection. At each stopping point in the erection sequence, have a competent contractor's representative inspect the beams to ensure adequate stability.

Do not begin any erection work without the Engineer's approval. The Engineer's approval does not relieve the Contractor of the responsibility for the safety of its method or equipment or from carrying out the work in accordance with the Plans and Specifications.

602.43 Straightening Bent Material and Cambering

A. Straightening Bent Material

Straighten plates, angles, other shapes, and built-up members, when permitted by the Engineer, using methods that will not produce fracture or other damage. Straighten distorted members by mechanical means or, if approved by the Engineer, by the careful planned and supervised application of a limited amount of localized heat, except that heat straightening of ASTM A709 Grade 100W or ASTM A517 steel members shall be done only under rigidly controlled procedures, each

application subject to the approval of the Engineer. Ensure that the maximum temperature of the ASTM A709 Grade 100W and the HPS70W steels does not exceed 1100 °F. Do not apply heat directly on weld metal. In all other steels, do not allow the temperature of the heated area to exceed 1200 °F as determined by temperature indicating crayons, liquids, bimetal thermometers, or infrared thermometers (conductor or non-conductor).

Keep parts to be heat straightened substantially free of stress and from external forces, except stresses resulting from mechanical means used in conjunction with the application of heat.

Following the straightening of a bend or buckle, carefully inspect the surface of the metal for evidence of fracture. Fractured material will be rejected.

B. Cambering

Correct errors in camber in welded beams and girders of ASTM A709 Grade HPS70W and 100W material under rigidly controlled procedures, with each application subject to the Engineer's approval.

602.44 Misfits

Assume responsibility for all misfits, errors, and damage, and make the necessary corrections and replacements. The Engineer will allow the correction of minor misfits using small amounts of reaming, cutting, and chipping. However, immediately report any error in the shop fabrication or deformation resulting from handling and transportation that prevents the proper assembling and fitting up of parts by moderate use of drift pins or by a moderate amount of reaming and slight chipping or cutting. Obtain the Engineer's approval of the proposed method of correction. Perform the correction in the Engineer's presence.

602.45 Assembling

Accurately assemble parts as shown on the working drawings, and follow all match-marks. Carefully handle the material so that no parts will be bent, broken, or otherwise damaged. Do not perform any hammering that will damage or distort the members. Clean bearing surfaces and surfaces to be in permanent contact before assembling the members. Unless erected by the cantilever method, erect truss spans on blocking that is placed to give the trusses proper camber. Leave the blocking in place until the tension

chord splices are fully connected with permanent fasteners and all other truss connections pinned and erection bolted. Do not permanently fasten splices of butt joints of compression members and railing until the span has been swung. For splices and field connections, fill one-half of the holes with erection bolts and cylindrical erection pins (half erection bolts and half pins) before placing permanent fasteners.

Use fitting-up bolts that are of the same nominal diameter as the permanent fasteners and cylindrical erection pins that are 1/32 inch larger.

602.46 Pin Connections

Furnish pilot and driving nuts for use in driving pins at no cost to the Department. Drive pins so that the members fully bear on the pins. Screw pin nuts tight and burr the threads at the face of the nut with a pointed tool.

602.47 Setting Shoes and Bearings

Do not place shoes and bearing plates on bridge seat bearing areas that are improperly finished, deformed, or irregular. Set shoes and bearing plates level in exact position and to have full and even bearing. Unless otherwise specified, the Contractor may use any of the following methods to set shoes and bearing plates:

1. A preformed fabric pad composed of multiple layers of 8-ounce duck impregnated and bound with high quality natural rubber or of equivalent and equally suitable materials compressed into resilient pads of uniform thickness. The number of plies shall be such as to produce a thickness of 1/8 inch after compression and vulcanizing. The finished pads shall withstand compression loads perpendicular to the plane of the laminations of not less than 10,000 pounds per square inch without detrimental reduction in thickness or extension.

2. Elastomeric Bearing Pads.

3. Grouted Bearing Plate.

Do not place any load on them until the grout has set for at least 96 hours. Take adequate provisions to keep the grout well moistened during this period. The grout shall consist of one part Portland cement to one part mortar sand.

Unless otherwise shown on the Plans or conditionally approved by the Engineer, cast anchor bolts into the masonry. If the Engineer approves the drilling of holes for setting anchor bolts, set the bolts accurately, and completely fill the holes with grout meeting the requirements of **921.09**. The location of the anchor bolts in relation to the slotted holes in the expansion shoes shall correspond with the temperature at the time of erection. Adjust the nuts on anchor bolts at the expansion ends of spans to allow the free movement of the span.

602.48 Painting

Unless otherwise shown on the Plans or specified in the Contract, perform shop and field painting in accordance with the **603**. Pay special attention to **603.06**.

Grease rollers, when not painted, with hard grease that will readily adhere to the metal in cold and hot weather. Paint the ends of rollers with the same kind and type of paint as the rest of the structure.

COMPENSATION

602.49 Method of Measurement

The Department will measure metal in a structure by the unit, lump sum, when the item is designated "Steel Structures" and by the pound when the item is designated "Structural Steel."

The Department will calculate weight for Structural Steel on the following bases:

A. Unit Weights, (pound per cubic foot)

The Department will use the material unit weights specified in Table 602.49-1.

Table 602.49-1: Material Unit Weights

Materials	Unit Weight (pound per cubic foot)
Aluminum, cast or wrought	173.0
Bronze	536.0
Copper-Alloy	536.0
Copper-Sheet	558.0
Iron, cast	445.0
Iron, malleable	470.0
Iron, wrought	487.0
Lead, sheet	707.0
Steel, rolled, cast, copper bearing, silicon, nickel and stainless	490.0
Zinc	450.0

B. Shapes and Plates

The Department will compute the weight of rolled shapes, and of plates up to and including 36 inches in width, on the basis of their nominal weights and dimensions, as shown on the Plans, deducting for cuts, and open holes.

The Department will compute weights of plates wider than 36 inches on the basis of their dimensions as shown on the Plans, deducting for cuts and holes. To this will be added one-half of the "Permissible Variation in Thickness and Weight," as tabulated in ASTM A6, General Requirements for Delivery of Rolled Steel Plates, Shapes and Bars for Structural Use.

C. Castings

The Department will compute the weight of castings from the dimensions shown on the approved shop drawings, deducting for open holes. To this weight will be added 5% allowance for fillets and overrun. Scale weights may be substituted for computed weights of castings or of small complex parts for which accurate computations of weight would be difficult.

D. High Strength Bolts

The Department will include the weight of heads, nuts, single washers, and threaded stick-through of all high tensile strength shop bolts on the basis of the weights shown in Table 602.49-2.

Table 602.49-2: Weight of High Strength Bolts

Diameter of Bolt (inches)	Weight per 100 Bolts (pounds)
1/2	19.7
5/8	31.7
3/4	52.4
7/8	80.4
1	116.7
1-1/8	165.1
1-1/4	212.0
1-3/8	280.0
1-1/2	340.0

E. Welds

The Department will base the weight of shop and field fillet welds on the weights shown in Table 602.49-3.

Table 602.49-3: Weight of Shop and Field Fillet Welds

Size of Weld (inches)	Pounds per Linear Foot
1/4	0.20
5/16	0.25
3/8	0.35
1/2	0.55
5/8	0.80
3/4	1.10
7/8	1.50
1	2.00

F. Shear Connectors

The Department will compute weights of shapes for shear connectors on the basis of their nominal weights per foot as shown on the approved shop drawings.

The Department will compute weights of spirals for shear connectors on the basis of the weights per foot as shown on the approved shop drawings.

The weight of stud bar shear connectors will be based on Table 602.49-4.

Table 602.49-4: Weight of Stud Bars

Diameter of Shank (inches)	Weight per inch of Shank (pounds)	Weight of Head (pounds)
3/4	0.125	0.174
7/8	0.170	0.210
1	0.223	0.250

G. Miscellaneous

The Department will not include the weight of temporary erection bolts, shop and field paint, boxes, crates, and other containers used for

shipping, and materials used for supporting members during transportation and erection.

H. Other Items

The Department will measure quantities of other Contract items that enter into the completed and accepted structure for payment in the manner prescribed for the items involved.

602.50 Basis of Payment

The Department will pay for accepted quantities on a unit price per pound or on a lump sum basis, as required by the Contract and as follows:

A. Structural Steel – Per Pound

Under Contracts containing an item for Structural Steel, all metal parts, other than metal reinforcement for concrete and metal piling, such as anchor bolts and nuts, shoes, rockers, rollers, bearing and slab plates, pins and nuts, expansion dams, weld metal, bolts embedded in concrete, and cradles and brackets, will be considered as structural steel, unless otherwise specified. The Department will pay for accepted quantities of structural steel at the contract unit price per pound for Structural Steel.

B. Steel Structures – Lump Sum

When the bid schedule calls for a lump sum price for Steel Structures, the Department will pay for the item at the contract lump sum price, complete in place and accepted.

The Department will not pay for materials used in standard tests, unless otherwise indicated on the Plans or in the Special Provisions.

The Department will pay for full size fabricated structural members or eye-bars that are tested in accordance with the Specifications, when such tests are indicated on the Plans or in the Special Provisions, at the same rate as for comparable members in the structure. The Department will not pay for members that fail to meet Contract requirements and members that are rejected as the result of tests.

The cost of drilling anchor bolt holes is incidental to other pay items.

The estimate of the weight for steel structures shown on the Plans is approximate only, and no guarantee is made that it is the correct weight to be furnished. The Department will not adjust the contract price if the weight furnished is more or less than the estimated weight.

If the Engineer directs changes in the work that modify the weight of steel to be furnished, the Department will adjust the lump sum payment as follows:

1. The Department will determine the value per pound of the increase or decrease in the weight of structural steel involved in the change by dividing the contract lump sum amount by the weight of steel in the original structure(s).

2. To determine the adjusted contract lump sum payment, the Department will take the contract lump sum amount, plus or minus the value of the steel involved in the change. The Department will not allow any additional compensation for such change.

SECTION 603 – PAINTING

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DESCRIPTION

603.01 Description

A. General

This work consists of surface preparation, paint application, furnishing protection from paint spatter and disfigurement, and final cleanup. The type, color, and number of paint coats shall be as specified in **603.06** and as shown on the Plans.

Each coat, for all systems, shall have a contrasting tint to aid in even application and inspection.

B. Certification Requirements

All contractors or subcontractors involved in field surface preparation or coating application shall be certified according to the Society for Protective Coatings (SSPC) Painting Contractor Certification Program (PCCP).

Contractors or subcontractors performing field coating application shall be certified according to SSPC QP1, Field Application.

Contractors and subcontractors performing field surface preparation of existing structures shall be certified according to SSPC QP2, Field Removal of Hazardous Coatings.

Ensure that all contractors and subcontractors that perform field surface preparation or field coating application are certified to the requirements of SSPC QP1 or QP2 before Contract award, and remain certified for the duration of the Project. If a contractor's or subcontractor's certification expires or is suspended, do not allow that contractor to perform any work until the certification is reissued or reinstated. The Department will not consider any requests for time extensions for any delay in the completion of the Project due to an inactive certification and may apply liquidated damages. Provide a copy of the certifications to the Engineer before beginning work and notify the Engineer of all changes in certification status.

MATERIALS

603.02 Materials

Provide materials as specified in:

Paint **910**

Unless otherwise specified, use paint manufactured and prepared to comply with the applicable specifications including those included by reference.

603.03 Reserved

CONSTRUCTION REQUIREMENTS

603.04 Clearing and Removing Obstructions

Cut or clear trees, limbs, bushes, grass, and other items that will damage or prevent satisfactory painting. Remove and replace as directed by the Engineer all obstructions or other items that will prevent proper paint application. Take care in removing the obstructions so as not to impair their usefulness when replaced. Replace damaged items at no cost to the Department.

603.05 Preparing Surfaces

A. New Structures

Prepare all metal surfaces to a condition equivalent to SSPC SP10 (Near White Blast Clean).

Prepare the fabricated steel to have a surface profile of 1 mil minimum to 2.5 mils maximum before applying the shop coat. Verify the surface profile obtained on the prepared surface according to ASTM D4417, Method A, B, or C.

B. Existing Structures

Prepare metal surfaces for painting as shown on the Plans and in accordance with these Specifications.

Unless otherwise specified, the Contractor may use any of the following methods to clean the metal:

1. **Hand (SSPC-SP2) or Power Tool (SSPC-SP3) Cleaning.** Use bristle or wood fiber brushes to remove loose dust. Remove oil and grease with solvents according to SSPC SP1. Use solvents that are safe and biodegradable.

2. **Blast Cleaning.** Use SSPC-SP10 for System A, or as shown on the Plans for Systems B and C. Blast cleaning shall leave a surface profile acceptable to the paint manufacturer.

For dry-blasted surfaces, remove all traces of blast products from the surface and abrasive from pockets and corners by brushing the surface with clean brushes made of hair, bristle, or fiber, using compressed air (from which detrimental oil and water have been removed) to blow off such residue, or cleaning with a vacuum.

For wet-abrasive-blasted surfaces, clean by rinsing with fresh water, to which sufficient corrosion inhibitor has been added to prevent rusting, or with fresh water, followed immediately by an inhibitive treatment approved by the paint manufacturer. Supplement this cleansing by brushing if necessary to remove residue.

Ensure that the compressed air used for nozzle blasting is free of detrimental amounts of water or oil. Provide adequate separators and traps. In the presence of the Engineer, test for the presence of oil or water in the compressed air in accordance with ASTM D4285.

Perform blast cleaning operations so that no damage is done to partially or entirely completed portions of the Work.

Remove all traces of oil, grease, or smudges deposited in the cleaning operations from blast-cleaned surfaces. Obtain the Engineer's approval of the cleaning before painting.

Ensure that the appearance of the surface after blast cleaning corresponds with the pictorial standards A SP-10, B SP-10, C SP-10, or D SP-10 of SSPC-VIS 1.

3. **Water Washing.** Use a high pressure water wash to remove all chalk, loose coatings, and other contaminants. High pressure water wash is defined as using pressure from 3,000 to 4,000 pounds per square inch at 8 to 10 gallons per minute.

603.06 Schedule of Painting

A. New Structures

Unless otherwise specified, paint all structural steel and other exposed metal by the paint systems specified in Table 603.06-1.

Table 603.06-1: System A – Inorganic Zinc

Paint System	Specification	Minimum Dry Film Thickness (mils)	Maximum Dry Film Thickness (mils)
Primer (shop coat)	Inorganic Zinc Silicate Paint, **910.03**	2.5	5.0
Intermediate Tie Coat	**910.03**, as modified below	2.0	5.0
Finish Coat (color coat)	Urethane Finish, **910.03** (match color shown on the Plans)	2.0	5.0

Only apply primer in the fabrication shop. Apply the intermediate tie coat and finish coat in the field. To ensure compatibility between coats, obtain all paint (primer, intermediate tie coat, and finish coat) from the same manufacturer.

B. Existing Structures

Unless otherwise shown on the Plans, paint all metal surfaces of existing structures with one of the systems specified in Tables 603.06-2 or 603.06-3, or System A, as specified in **603.06.A**. To ensure compatibility between coats, obtain all paint (spot primer, primer, and finish coat) from the same manufacturer.

Table 603.06-2: System B

Paint System	Specification	Minimum Dry Film Thickness (mils) [2]	Maximum Dry Film Thickness (mils) [2]
Spot Primer	Epoxy Mastic [1]	2.0	5.0
Primer	Epoxy Mastic [1]	3.0	5.0
Finish Coat (color coat)	Urethane Finish, **910.03** (match color shown on the Plans)	2.0	5.0

[1] Material to be on Qualified Products List maintained by the Division of Materials and Tests.

[2] The primer dry film thickness is measured above the surface profile.

Table 603.06-3: System C

Paint System	Specification	Minimum Dry Film Thickness (mils) [2]	Maximum Dry Film Thickness (mils) [2]
Spot Primer	Universal [1]	2.0	5.0
Primer	Universal [1]	3.0	5.0
Finish Coat (color coat)	Urethane Finish, **910.03** (match color shown on the Plans)	2.0	5.0

[1] Material to be on Qualified Products List maintained by the Division of Materials and Tests.

[2] The primer dry film thickness is measured above the surface profile.

603.07 Weather Conditions

Do not apply paint:

1. When either the ambient or steel surface temperature exceeds 100 °F or is below 40 °F, unless the Engineer approves otherwise in writing.

2. To steel that is at a temperature that will cause blistering or porosity, or otherwise will be detrimental to the life of the paint.

3. When the relative humidity exceeds 85%.

4. During rain, snow, fog, or misty conditions, or when the steel surface temperature is less than 5 °F above the dew point.

603.08 Storing Paint

If paint is to remain in storage for a considerable length of time, turn the containers end for end at least once a week. The Engineer will re-inspect paint that has been in storage for longer than 6 months before approving its use. Store paint according to the manufacturer's recommendations. Do not allow the paint to freeze.

603.09 Mixing Paint

Thoroughly mix paint before applying. Ensure that the pigments remain in uniform suspension during application. Perform mixing by mechanical methods, except that hand mixing will be permitted for containers less than 5 gallons in size. When special paint is specified, mix it according to the manufacturer's recommendation.

603.10 Applying Paint

A. General

Submit the manufacturer's current printed instructions for applying the paint system specified to the Engineer for approval. Follow the instructions, as approved, unless otherwise directed by the Engineer.

Apply paint by brushing, spraying, or a combination of these methods. The Contractor may use daubers or sheepskins if no other method is practicable to properly apply paint in places of difficult access. Only use dipping, roller coating, or flow coating when specifically authorized.

To the maximum extent practicable, apply each coat of paint as a continuous film of uniform thickness free of pores. Repaint all thin spots or areas missed in the application, and allow to cure before applying the next coat of paint.

Ensure that each coat of paint is in a proper state of cure before applying the succeeding coat.

B. Spray Application

Spray application of paint, whether air spray, airless spray, hot air spray, or hot airless spray, shall be in accordance with the following:

Use equipment suitable for the intended purpose, that is capable of properly atomizing the paint to be applied, and that is equipped with suitable pressure regulators and gauges. Maintain the equipment in proper working condition. Keep spray equipment so that dirt, dried paint, and other foreign materials are not deposited in the paint film. Remove solvents left in the equipment before using.

1. Air Spray. Use the air caps, nozzles, and needles recommended by the manufacturers of the material being sprayed and the equipment being used.

Provide adequately sized traps or separators to remove oil and condensed water from the air. Periodically drain the traps or separators during operations. Ensure that the air from the spray gun impinging against a clean surface shows no sign of condensed water or oil. Adjust the pressure on the material in the pot when necessary for changes in elevation of the gun above the pot. The atomizing air pressure at the gun shall be high enough to properly atomize the paint, but not so high as to cause excessive fogging of paint, excessive evaporation of solvent, or loss by over-spray.

2. Airless Spray. Use fluid tips of proper orifice and fan angle, and a fluid control gun of proper construction, as recommended by the manufacturer of the material being sprayed and the equipment being used. Fluid tips shall be of the safety type with shields.

Adjust the air pressure to the paint pump so that the paint pressure to the gun is proper for optimum spraying effectiveness. This pressure shall be sufficiently high to properly atomize the paint. Do not use pressures considerably higher than that necessary to properly atomize the paint.

Keep spraying equipment clean, and use proper filters in the high pressure line so that dirt, dry paint, and other foreign materials are

not deposited in the paint film. Remove all solvent left in the equipment before applying paint.

Provide airless paint spray equipment with an electric ground wire in the high-pressure line between the gun and the pumping equipment. Ensure that the pumping equipment is suitably grounded to avoid the build-up of any electrostatic charge on the gun.

C. Brush Application

Use brushes of a style and quality that will enable proper application of paint. Round or oval brushes are generally considered most suitable for bolts, irregular surfaces, and rough or pitted steel. Wide, flat brushes are suitable for large flat areas, but they should not have a width over 5 inches. Length of the bristles should be equal to or exceed the brush width.

Brush so as to obtain a smooth coat, as nearly uniform in thickness as possible. Brush subsequent coats in a direction perpendicular to that of the previous coat. Typically brushed coats are thinner than sprayed coats and additional brushed coats may be needed to achieve the proper film thickness. Work paint into all crevices and corners. Use spray, daubers, or sheepskins to paint surfaces not accessible to brushes. Brush out all runs or sags.

D. Roller Application

The Contractor may use rollers to apply paint on flat or slightly curved surfaces. Roller application shall be in accordance with the recommendations of the paint manufacturer and roller manufacturer. Use paint rollers of a style and quality that will allow proper application of paint having the continuity and thickness required in Section 6.7 and 6.8 of SSPC-PA 1. The coating shall not contain any nap from the roller.

Do not apply paint using rollers on irregular surfaces such as bolts, crevices, welds, corners, or edges, unless otherwise specified. When permitted, however, subsequently brush out the paint applied by roller on these irregular surfaces to form a continuous and unbroken film.

603.11 Shop Painting

Unless otherwise specified, apply one coat of primer paint to steelwork after it has been accepted by the inspector and before it is shipped from the plant. The shop coat of paint shall meet the dry film thickness specified in **603.06** for the paint system being supplied.

Paint surfaces that are not in contact, but inaccessible after assembly, with three coats of shop paint. The shop contact surfaces and field contact surfaces within friction type joints shall be free of oil, paint, lacquer, galvanizing, or rust inhibitor. Apply a coat of shop paint to other field contact surfaces, except for main splices for chords of trusses and large girder splices involving multiple thicknesses of material where a shop coat of paint would make erection difficult.

Do not paint structural steel that is to be welded before welding is complete. If it is to be welded only in the fabricating shop and subsequently erected by bolting, apply one coat of paint after shop welding is finished. Do not apply shop paint to steel in the area where field welding will be performed.

Coat machine-finished surfaces for sliding contact with an approved lubricant, as soon as practicable after being accepted and before removal from the shop.

Paint erection marks for field identification of members and weight marks on surface areas previously painted with the shop coat. Do not load material for shipment until it is thoroughly dry, and in no case, less than 24 hours after applying the paint.

Design bolted faying surfaces for a Class B surface. Ensure the faying surfaces are prepared to provide a slip coefficient at least equal to that required for a Class B surface. Provide a certification that the paint used will provide the required resistance at the proposed thickness.

Do not move or handle painted steel until sufficient cure time has elapsed to ensure no damage is done to the fresh coating. Insulate the steel from the binding chains by softeners approved by the Engineer. Provide padding for hooks and slings used to hoist steel. Space diaphragms and similar pieces in such a way that no rubbing will occur during shipment that may damage the coatings. Store the steel on pallets at the jobsite, or by other means approved by the Engineer, so that it does not rest on the dirt and so that components do not fall or rest on each other.

603.12 Field Painting

Apply the intermediate coat and finish coat for steel structures in the field, after erection is complete, except as specified in **603.11**.

Before painting operations begin:

1. Obtain the Engineer's approval of a containment system designed to prevent release of surface preparation debris, dust, drippings, and over-spray into the environment.

2. Develop a contingency plan for cleanup of inadvertent spills of paint.

3. Submit a copy of the contingency plan to the Engineer, along with a list of the equipment and personnel that will implement the plan.

4. Have on the jobsite, and approved, the personnel, equipment, and material necessary to contain both spillage and over-spray. Keep onsite the following items, as a minimum:

    a. 55-gallon drum of sand,
    b. Biodegradable cleaners and degreasers, and
    c. Boom skimmer collector and boat with motor for over water work.

Limit and contain over-spray by following prudent application procedures in accordance with the specifications, taking into account the ambient climatic conditions. Use drop-cloths, screens, and similar measures to prevent contamination of the soil, adjacent properties, and streams or ponded surface water.

Immediately clean up spills or over-spray and concurrently report the occurrence to the Tennessee Department of Environment and Conservation (TDEC) and the Engineer. Also notify the Tennessee Emergency Management Agency (TEMA) where deemed appropriate.

Prominently display a copy of the contingency plan, including emergency phone numbers, at the jobsite.

For each field coat of paint, apply the dry film thickness specified in **603.06** for the paint system being used. Where measurement of dry film thickness

may become difficult or dangerous, the Engineer may allow wet film measurement. In such cases, the Engineer will predetermine and notify the Contractor of the required wet film thickness, for each type of paint, to comply with the dry film thickness specified.

Sand to remove excessive thickness from areas of each coat that have dry film thickness over the maximum specified or that have runs and sags. Touch up areas of the finish coat after sanding to provide a uniform appearance.

Touch up metal that has been shop coated with the same paint as the shop coat. This touch-up shall include cleaning and painting of field connections, welds, and all damaged or defective paint and rusted areas. The Contractor may apply an overall coat of primer in place of touch-up or spot painting.

Before erection, apply all field coats of paint to surfaces (other than contact surfaces) that will be inaccessible after erection. Only apply shop primer to surfaces that will be in contact with concrete.

If concreting or other operations damage paint, clean and repaint the surface. Before applying any paint, remove all cement or concrete spatter, drippings, and other debris that would interfere with repainting the damaged area.

When traffic produces an objectionable amount of dust, allay the dust for the necessary distance on each side of the bridge, and take all other precautions necessary to prevent dust and dirt from coming in contact with freshly painted surfaces or with surfaces before the paint is applied, at no cost to the Department.

603.13 Repainting Existing Steel Structures

Clean and prepare all metal surfaces to be repainted as specified in **603.05.B**, unless otherwise specified, and repaint with the paint system shown on the Plans. Apply paint as specified in **603.12**. Unless otherwise shown on the Plans, take the following precautions to remove, contain, and dispose of the surface preparation waste and paint removal media.

A. General

Before starting surface preparation, take soil and water samples at the bridge site. Have the samples analyzed by EPA Test Method 1311,

Toxicity Characteristic Leaching Procedure (TCLP), to determine existing metal and organic content.

Contain all waste debris in an enclosed system using air moving equipment capable of creating a negative pressure inside the enclosure to prevent release of debris or dust into the environment, with the following exception: equipment capable of creating a negative pressure will not be required when surface preparation is performed using high pressure water or when paint removal is confined to localized surface areas such as bearings and beam ends and where removal of the paint is accomplished by a containment means, approved by the Engineer, that precludes the release of removal waste into the environment. Do not perform any surface preparation activities when weather conditions, as determined by the Engineer, preclude effective containment of waste debris and dust.

When a high pressure water wash is specified, perform a preliminary wash test on a representative area of 50 square feet of the structural steel that is to be cleaned and painted, in order to collect a minimum of two samples of the debris in the used wash water. Take the samples in the presence of a Department representative and have them analyzed for metal and organic content using the TCLP test method. If samples do not exceed threshold values for a characteristic waste, provide containment consisting of screens, water permeable tarps, or both. Place these screens or tarps around the work area so as to contain all paint chips or other solid wastes generated by the water wash operations. If samples exceed threshold values for a characteristic waste, use as containment water impermeable material capable of containing all waste including the wash water.

Before starting the work, obtain all required permits and supply copies to the Engineer.

B. Containment

1. General. Before starting surface preparation at each bridge, submit the design drawings of the containment system for surface preparations to the Engineer for review. See SSPC Guide 6, *Guide for Containing Surface Preparation Debris Generated During Paint Removal Operations*. There shall be no visible emissions from the containment.

From SSPC Guide 6:

a. Blast clean: minimum Class 2A, visual negative pressure verification
b. Water wash: Class 2W
c. Hand and power tool clean with vacuum shroud: Class 3P
d. Hand and power tool clean without vacuum shroud: Class 2P

2. Submittal Requirements. Include the following in the submittal:

a. Provide an analysis of the load that will be added to the existing structure by the containment system and waste materials. The load analysis shall ensure that the system will not induce a load on the bridge that will create an overstress condition or otherwise affect the structural integrity of the bridge. Retain a civil engineer licensed by the State of Tennessee to prepare and seal the analysis. The containment system or equipment shall not encroach upon the minimum bridge clearances shown on the Plans, unless otherwise approved by the Engineer.

   The Engineer's review and acceptance of the load analysis in no way relieves the Contractor of responsibility for the structural safety of the containment system.

b. Provide a work phase diagram describing how the debris is to be contained and collected during surface preparation operations, including material specifications and details for containment structures (connections, frame, supports, enclosure sheeting, etc.) and type of blast media. Properly maintain the containment system while work is in progress and do not deviate from the approved working drawings without the Engineer's prior approval. Deny public access to rigging, scaffolding, and containment systems.

c. Provide a contingency plan for environmental cleanup of a containment system failure or spill that releases surface preparation debris into the environment. Maintain a copy of the contingency plan and all materials and equipment required to implement the cleanup at the jobsite at all

times during surface preparation and containment operations.

If a containment system fails or a spill occurs, immediately notify the Tennessee Department of Environment and Conservation (TDEC). Suspend all operations except those activities required to implement the contingency plan for cleanup. Do not resume surface preparation operations until modifications have been made to correct the cause of the failure or spill.

d. Identify the location and type of temporary storage area for contaminated debris pending its final disposition.

C. Storage and Disposal

Place all waste collected in the containment system in approved containers, tagged with the bridge number, contract number, Contractor's name, contents, and the date. Haul the containers daily, or as directed by the Engineer, to a storage area that will prevent spillage and migration of the waste into the environment. The storage area shall provide protection from vandalism and unauthorized access by the general public and shall be approved by the Engineer.

Collect a representative, composite sample for each 10 cubic yards, or portion thereof, of all waste as it is generated. Retain an approved independent testing laboratory to analyze all samples for metals and organic content using EPA Test Method 1311, Toxicity Characteristic Leaching Procedure (TCLP).

The TCLP test report for each composite sample shall show the percentage of the toxic metals and their respective threshold values. Waste not exceeding the threshold for a characteristic waste may be disposed of as an industrial waste in any landfill permitted to handle this material.

Handle all waste that exceeds the threshold for a characteristic waste as a hazardous waste. Comply with all hazardous waste rules and regulations of the EPA and the Tennessee Department of Environment and Conservation (TDEC).

Do not store any hazardous waste at the temporary storage site for more than 90 days after the date of generation. Transport all hazardous waste

using a permitted transporter, and dispose of this waste in an authorized hazardous waste facility. As the co-generator of the waste, the Contractor shall sign the manifests and other required documents.

Provide a copy of all test reports, transportation manifests, and confirmation of disposal to the Engineer before acceptance of the Project.

D. Worker and Public Safety

Ensure that all personnel involved in the generation and handling of the waste are trained in accordance with EPA/Occupational Safety and Health Administration (OSHA) directives. Comply fully with 29 CFR 1926.62 for worker and public safety protection. Provide adequate respiratory protection and protective clothing to all exposed workers, including Department employees when their inspection duties subject them to exposure. The protection provided shall meet OSHA requirements.

Contain all waste generated by surface preparation so as to not cause a public hazard.

After metal surfaces have been cleaned and prepared, paint existing steel structures in accordance with **603.06** or as otherwise specified.

603.14 Protection of Traffic

Protect the environment and the traveling public, both vehicular and pedestrian, from injury or damage during the progress of painting. These precautions may include, but are not limited to, erecting suitable coverings, protective screens, warning signs, and barricades. The Contractor shall be directly and solely responsible for injury and damage incurred and hereby agrees to hold the Department and its employees harmless therefrom.

603.15 Protection of Structures and Surfaces

Protect all portions of the structure against damage by splatter of paint or paint materials. Clean and restore to original condition all surfaces damaged by paint splatter at no cost to the Department.

603.16 Final Cleanup

Perform final cleanup as specified in **104.10**.

COMPENSATION

603.17 Method of Measurement

A. Painting Steel Structures

Unless otherwise specified, the Department will consider the painting of steel structures to be incidental to the price bid for Structural Steel.

When the Contract includes an item for Painting Steel Structures on a lump sum basis, the Department will measure painting a structure or structures, as shown on the Plans, as one unit.

B. Repainting Existing Steel Structures

The Department will measure Repainting Existing Steel Structures for payment on a lump sum basis for each unit. The repainting of a structure or structures as shown on the Plans will be considered as one unit.

C. Containment and Disposal of Waste

The Department will measure Containment and Disposal of Waste for payment on a lump sum basis for each unit. The containment and disposal of surface preparation wastes for a structure or structures as shown on the Plans will be considered one unit.

When the Contract does not include pay items for containment and disposal of waste, consider such work to be incidental to other items of construction.

603.18 Basis of Payment

When provided for in the Contract, the Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Painting Steel Structures (Location and Description)	Lump Sum

Repainting Existing Steel Structures	
(Location and Description)	Lump Sum
Containment and Disposal of Waste	
(Location and Description)	Lump Sum

When the Contract includes an item for Painting Steel Structures, such payment is full compensation for preparing the surface and furnishing and applying the paint.

Payment for Repainting Existing Steel Structures is full compensation for obtaining all permits and preparing the surface, including removing paint and furnishing and applying the paint.

Payment for Containment and Disposal of Waste is full compensation for obtaining all permits, including all fees and costs thereof, containing surface preparation waste, furnishing containers and placing waste therein, and testing, transporting, and disposing of all surface preparation waste.

The Department will deduct fines incurred by the State as a result of the Contractor's operation from monies due to the Contractor.

SECTION 604 – CONCRETE STRUCTURES

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DESCRIPTION

604.01 Description

This work consists of constructing all structures or parts of structures composed of Portland cement concrete, whether plain, reinforced, or a combination of both, on prepared foundations, at the locations shown on the Plans or as directed by the Engineer.

Use concrete consisting of a mixture or mixtures of Portland cement, aggregates, air-entraining agents, water, and chemical additives when approved, combined by the methods specified herein and in the proportions specified for the designated class of concrete.

Construct parts of a structure, or structures, which are to be constructed with materials other than Portland cement concrete and concrete reinforcement steel, as specified in the Section of these Specifications covering the particular type of construction.

MATERIALS

604.02 Materials

A. General

Provide materials as specified in:

Hydraulic cement[1] **901.01**
Fine Aggregate, (all Classes of concrete) **903.01**
Coarse Aggregate
For Class A Concrete: Size No. 57 ..... **903.03**
For Class D Concrete: Size No. 57 ..... **903.03**

[1]Use Type I, Type IL, or Type IS unless otherwise specified or permitted, or Type I or Type IL cement with either fly ash and/or ground granulated blast furnace slag as a partial cement replacement unless otherwise specified or permitted. When using Type I or Type IL cement with either fly ash and/or ground granulated blast furnace slag as a partial cement replacement, comply with the requirements of **604.03**.

For Class L Concrete **903.19**
Joint Filler, Preformed Type **905.01**
Steel Bar Reinforcement **907.01**
Welded Steel Wire Fabric **907.03**
Structural Steel **908.01**
Permanent Steel Bridge Deck Forms **908.03**
Steel Castings **908.05**
Gray Iron Castings **908.07**
Bronze Bearing Plates, Plain **908.09**
Bronze Bearing Plates, Self-Lubricating **908.10**
Elastomeric Bearing Pads **908.12**
Paints **910**
Cement Concrete Curing Materials **913**
Precast Concrete Box Culverts **914.08**
Water **921.01**
Chemical Additives for Concrete **921.06**
Air-Entraining Admixtures **921.06**
Waterstops **921.08**
Precast Prestressed Bridge Deck Panels **921.13**
Applied Texture Finish **921.14**
Fly Ash **921.15**
Ground Granulated Blast Furnace Slag **921.16**

B. Fly Ash and Ground Granulated Blast Furnace Slag as a Partial Cement Replacement

Do not use fly ash or ground granulated blast furnace slag of different classes or sources as partial replacement for Portland cement in concrete mixes. Only use fly ash or ground granulated blast furnace slag as a partial cement replacement in Type I or Type IL Portland cement. The Department will allow a maximum of 20% fly ash as a partial hydraulic cement replacement in Type IS cement only in Class A concrete.

Do not begin producing concrete with fly ash as a partial cement replacement until the concrete supplier furnishes the information specified in **501.02.B.1** to the Engineer.

Do not begin producing concrete with ground granulated blast furnace slag as a partial cement replacement until the concrete supplier furnishes the information specified in **501.02.B.2** to the Engineer.

C. Precast Box Sections

Unless otherwise shown on the Plans, for fill heights less than or equal to those shown in the standard box culvert drawings for cast-in-place concrete box sections, the Contractor may substitute precast reinforced box sections meeting **914.08** and the standard box culvert drawings for precast box culverts.

Submit shop drawings of the proposed precast box section and design calculations for approval before construction. As a minimum, the shop drawings shall include a plan and elevation view of the box culvert showing all precast sections, a typical precast box section showing dimensions and reinforcing, and notes and details required for construction. After obtaining the necessary approval, furnish the Structures Division a permanent, 4-mil mylar reproducible of the design for their file. The Department will pay the Contractor for the precast box based on the price bid for the quantity of the items in the cast-in-place structure it replaces. Manufacture the precast reinforced box sections in accordance with Departmental procedures.

For fill heights greater than those shown in the standard box culvert drawings for cast-in-place concrete box sections or other non-standard designs, the Contractor may submit for consideration a value engineering change proposal in accordance with **104.11**.

604.03 Classification, Proportioning and Quality Assurance of Concrete

A. Classification and Proportioning and Quality Assurance

1. **Design and Production Parameters.** Proportion the concrete based on a pre-determined minimum cement content, and a water-cement ratio that does not exceed the maximum shown in Table 604.03-1. Below this limit, adjust the quantity of water to meet the slump requirements. The fine aggregate shall not exceed 44% by volume calculation of the total aggregate, with the exception of slip formed Class A concrete incorporated into parapets and median barriers.

   For slip formed parapet and median barriers exclusively, the percentages of fine and coarse aggregate in an approved concrete mix design may be adjusted plus or minus 2%, such that the

maximum percent by volume of fine aggregate does not exceed 46%.

Document mixture adjustments in the field book and daily concrete report. Ensure that the adjusted mix complies with all of the performance criteria specified in Table 604.03-1.

Table 604.03-1: Composition of Various Classes of Concrete

Class of Concrete	Min 28-Day Compressive Strength (psi)	Min Cement Content (pound per cubic yard)	Maximum Water/Cement Ratio (pound/pound)	Air Content % (Design ± production tolerance)	Slump (inches)
A	3,000	564	0.45	6 ± 2	3 ± 1 [1]
D [2, 3]	4,000	620	0.40	7 [3]	8 max [4]
L [3, 5]	4,000	620	0.40	7 [3]	8 max [4]
S (Seal) [6]	3,000	682	0.47	6 ± 2	6 ± 2
X [7]					

[1] For slip forming, the slump shall range from 0 to 3 inches.

[2] Use Class D concrete in all bridge decks except box and slab type structures unless otherwise shown on the Plans.

[3] Design Class D and Class L concrete at 7% air content. Acceptance range for pumping and other methods of placement is 4.5-7.5%. Sampling will be at the truck chute.

[4] Water reducing admixtures are acceptable; however, do not exceed the maximum water/cement ratio in order to achieve the required slump.

[5] The unit weight of air dried Class L concrete (lightweight concrete) shall not exceed 115 pounds per cubic foot as determined according to ASTM C567.

[6] The use of fly ash as a cement replacement will be allowed in Class S (Seal) concrete.

[7] Plan specific requirements

Include chemical admixtures in the concrete mixture as specified in Table 604.03-2 based on the ambient air temperature and expected weather conditions.

Table 604.03-2: Use of Chemical Admixtures

Class of Concrete	Temperature less than 85 °F and falling	Temperature 85 °F or greater and rising
A	Type A or F	Type D or G or A and B
D	Type A or F	Type A or F and B or G
L	Type F	Type F and B or G
S	Type D or G or A and B	Type D or G or A and B

If using a Type A, F, or G water reducer, then the allowable slump shall be a maximum of 8 inches.

Admixtures to be incorporated into the concrete shall all be from the same manufacturer, shall be compatible, and shall be incorporated into the concrete in accordance with the manufacturer's recommendations.

The fine aggregate in all Class L concrete shall be natural sand meeting **903.01.**

Do not use fine aggregate manufactured from limestone or other polishing aggregates in concrete to be used as a riding surface in traffic lanes.

2. Mix Design Submittal. Submit the proposed concrete design to the Engineer for approval. Develop the design using saturated surface dry aggregate weights and trial batches meeting the requirements of these Specifications. The concrete design shall be prepared by a TDOT certified Class 3 concrete technician or approved independent testing laboratory under the direction of a registered civil engineer licensed by the State of Tennessee. The concrete plant technician or the civil engineer shall certify that the information contained on the design is correct and is the result of information gained from the trial batches. The concrete design shall produce an average compressive strength to indicate that the specified 28-day strength can be obtained in the field. Make all strength determinations using equipment meeting the requirements

of, and in the manner prescribed by, AASHTO T 22. Provide concrete of the design strength specified in all applicable Special Provisions, Plans, and Standard Specifications. Build trial batches for design no more than 90 days before submitting the concrete design. The approved mix design will expire after 6 months if it is not used on a Department funded project and meet the minimum 28-day strength requirements. Assume responsibility for all costs of concrete design, preparation, and submittal.

As a minimum, include the following information in the proposed concrete design submittal:

1. Source of all aggregates
2. Brand and type of cement
3. Source and class of fly ash (if used)
4. Source and grade of ground granulated blast furnace slag (if used)
5. Specific gravity of cement
6. Specific gravity of the fly ash (if used)
7. Specific gravity of the ground granulated blast furnace slag (if used)
8. Admixtures (if used)
9. Gradations of aggregates
10. Specific gravity of aggregates (saturated surface dry)
11. Air content (if air entrainment is used)
12. Percentage of fine aggregate of the total aggregate (by volume)
13. Slump
14. Weight per cubic yard
15. Yield
16. Temperature of plastic concrete
17. Water/cement ratio (pound/pound)
18. 7-day compressive strength (minimum of three 4-inch x 8-inch cylinders)
19. 14-day compressive strength (minimum of three 4-inch x 8-inch cylinders)
20. 28-day compressive strength (minimum of three 4-inch x 8-inch cylinders)
21. Weight of each material required to produce a cubic yard of concrete

Instead of the above mix design submittal, the Contractor may submit for approval an existing design approved by the

Department within the current calendar year. The approval of this concrete design submittal will not relieve the Contractor of the responsibility of providing concrete meeting the requirements of these Specifications. A temporary mix design may be issued if the 7-day or 14-day compressive strengths exceed the required 28-day strengths.

If proposing to use materials or admixtures from sources other than those shown on the approved mix design, submit a written request to the Regional Materials and Tests Engineer explaining the necessity for the change, and include a new mix design developed in accordance with the above provisions. Do not place any concrete until the new design is approved.

3. Partial Cement Replacement with Fly Ash or Ground Granulated Blast Furnace Slag. Do not use concrete with fly ash or ground granulated blast furnace slag as a partial cement replacement in concrete when high early strength is specified.

When choosing to replace a portion of Type I or Type IL cement with fly ash or ground granulated blast furnace slag, ensure that the following requirements will be met before producing any concrete:

1. Store fly ash or ground granulated blast furnace slag in silos separate from each other and separate from the hydraulic cement.

2. Add the fly ash or ground granulated blast furnace slag to the concrete using methods and equipment that are approved by the Engineer and capable of uniformly distributing the materials throughout the mix.

3. The fly ash or ground granulated blast furnace slag may be weighed cumulatively in the weigh hopper with the cement, provided the cement is added first. The temperature of the fly ash or the ground granulated blast furnace slag shall not exceed 160 °F at the time of introduction to the mix.

When designing Portland cement concrete with Type I or Type IL cement modified by the addition of fly ash and/or ground granulated blast furnace slag, meet the maximum cement replacement rates (by weight) and minimum substitution ratios (by

weight) specified in Table 604.03-3 for the applicable type of modifier.

Table 604.03-3: Type I or Type IL Cement Modified by Fly Ash or Ground Granulated Blast Furnace Slag (GGBFS)

Modifier	Maximum Cement Replacement Rate % (by weight)	Minimum Modifier Cement Substitution Rates (by weight)
GGBFS (grade 100 or 120)	35.0	1:1
Class "F" Fly Ash	25.0	1:1
Class "C" Fly Ash	25.0	1:1

The Contractor may use ternary cementitious mixtures (mixtures with Portland cement, ground granulated blast furnace slag, and fly ash) for Class A and Class D concrete provided that the minimum Portland cement content is 50%. The maximum amount of fly ash substitution in a ternary cementitious mixture shall be 20%. The Department will allow Type IS cement with ternary cementitious mixtures. When using a Type IS cement, do not use any additional slag as a partial replacement for the hydraulic cement.

B. Quality Control and Acceptance of Concrete

Meet the requirements of **501.03.B**.

In addition, the Department will require an approved concrete design for non-critical items involving small quantities of concrete, but may accept these non-critical items at a reduced testing frequency in accordance with Department Procedures. This requirement applies to sidewalks, curbs and gutters, building foundations, slope paving, ditch paving, guardrail anchorages, small culvert headwalls 30 inches in diameter or less, fence posts, catch basins, manhole bases and inlets, small sign bases, and steel strain pole footings. The Contractor may use pre-approved, pre-packaged concrete mixtures for these applications if the quantity does not exceed 2 cubic yards per day, in which case no design will be required.

Correct batch weights to compensate for surface moisture on the aggregate at the time of use. The Contractor may withhold some of the

water from the mix at the plant and add it at the placement site as specified in **604.13**.

The Department will perform all acceptance testing and independent assurance sampling and testing in accordance with **501.03.B**.

C. High Early Strength

When the Plans for structural or pavement repairs, or other type work, require high early strength concrete, the Contractor may use Type I, Type IL, or Type III cement. If Type I or Type IL cement is used, the minimum cement content shall be 714 pounds per cubic yard. If Type III cement is used, the minimum cement content shall be 620 pounds per cubic yard. The Contractor may substitute high early strength concrete, meeting these requirements, for Class A concrete when approved in writing by the Engineer.

When electing to use high early strength concrete, use the same source and gradation of fine and coarse aggregates as that specified for the concrete being substituted. The Department will not make additional payment if the Contractor decides to substitute high early strength concrete for Class A concrete. The unit price for the class of concrete for which the substitution is made shall be full compensation for the concrete.

EQUIPMENT

604.04 Equipment

Obtain the Engineer's approval as to the design, capacity, and mechanical condition of equipment and tools used to handle materials and perform the work. Have the equipment on the jobsite sufficiently ahead of the start of construction operations to be examined and approved by the Engineer. Use equipment and construction processes that have sufficient capacity to accomplish the maximum continuous concrete placement, as governed by the construction joints shown on the Plans or as directed by the Engineer.

Meet the requirements for batching plants specified in **501.04.A**, except that when approved by the Engineer, the requirement for storage compartments in addition to weigh bins for fine and coarse aggregates may be waived, provided the batching tolerances specified in **501.09** are maintained.

Meet the requirements for mixers specified in **501.04.B**, except that the requirement for the boom-and-bucket attachment to the mixer will be waived.

Provide ample and satisfactory equipment for conveying concrete from the mixer to final position in the forms. Use closed chutes or pipes when concrete is to be dumped or dropped for a distance greater than 5 feet. Where steep slopes are required, equip the chutes with baffle boards, or use chutes in short lengths that will allow the direction of movement to be reversed.

Use vibrators of an approved type and design, and operate them under load at the rate recommended by the manufacturer and approved by the Engineer.

The Contractor may mix concrete for minor structures, as identified in **604.11.B**, in a mobile volumetric continuous mixing plant.

Use a mobile mixing plant that is:

1. Designed to accurately batch aggregates and cement by volume based on weight.

2. Equipped to perform mixing by a continuous auger and/or paddles.

3. Capable of producing a uniform concrete mix meeting all requirements of the Specifications.

4. Capable of carrying in separate compartments all the necessary ingredients needed for the concrete mix.

5. Equipped with calibrated proportional devices for each material.

6. Equipped with proportioning controls that they may be set and secured for different materials and mixes.

7. Equipped with separate bins and gate openings for each type of material, including a watertight storage bin for cement. Cover the aggregate bins with tarpaulins or by other approved methods when required.

Ensure that a metal plate identifying the discharge speed and weight-calibrated constant of the machine is attached to each unit.

Make adequate standard volume measures, scales, and weights available for checking the accuracy of the proportioning mechanism.

Furnish a calibrated chart for the individual unit when required by the Engineer.

In the Engineer's presence, the producer or factory representative shall perform the calibration and gate settings according to the manufacturer's recommendations for the design to be used.

Provide a satisfactory method of setting the dosage for admixtures. If using admixtures other than air-entraining agents, add them in the manner and in the dosage recommended by the manufacturer.

When placing concrete by pumping, do not use aluminum conduit.

Do not pour any concrete for bridge decks or slabs above grade before verifying the availability and operability of all necessary equipment, including finishing machines, continuous water source or portable tanks, water distribution equipment, two work bridges, vibrators, sprayers, a 12-foot straightedge, and appropriate backup items.

Provide at every concrete deck pour a portable, cold fogger capable of changing humidity and cooling air above fresh concrete. The fogger shall be designed to provide a maximum VMD (volume mean diameter) of 15 microns, and a throw distance of 60 feet.

CONSTRUCTION REQUIREMENTS

604.05 Forms

A. Construction

Forms shall be mortar-tight and sufficiently rigid to prevent distortion due to the pressure of the concrete and other stresses incidental to the construction operations, including vibration. Construct and maintain forms so as to prevent the opening of joints due to shrinkage of the lumber.

Build the forms true to line and grade. Hold the forms in place with studs or uprights, and waling, which shall be sufficiently and substantially braced and tied.

Cut off and cap all forms and studding with not less than a 2 x 4-inch piece.

Chamfer all exposed edges with 3/4-inch material, unless otherwise specified. All chamfer strips shall be straight, of uniform width, and dressed.

Remove wood devices used to separate forms before placing concrete within 4 inches of such devices.

B. Form Lumber

Dress form lumber for all exposed concrete surfaces on at least one side and two edges, and construct so as to produce mortar-tight joints and smooth, even concrete surfaces.

The Contractor may use plywood forms, or forms face-lined with plywood, masonite, or other approved similar material, provided the plywood forms and form linings are substantial, of uniform thickness, and are mortar-tight when in position.

C. Metal Ties

Construct metal ties or anchorages within the forms so as to allow their removal to a depth of at least 1 inch from the face without damaging the concrete. If wire ties are permitted, cut the wires back at least 1/4 inch from the surface of the concrete, and ensure that the surface is left sound, smooth, even, and uniform in color.

D. Walls

Provide sufficient openings at intervals along the bottom of wall forms to allow thorough cleaning before concrete placement. Close such openings before placing concrete in the forms.

E. Surface Treatment

Before placing reinforcement, treat all forms to prevent the adherence of concrete. Treat forms, which are not provided with a special treatment, with an approved oil. Do not use any material that will adhere to or discolor the concrete.

F. Metal Forms

Ensure that metal forms comply with all requirements for forms, as regards design, mortar tightness, filleted corners, beveled projections, bracing, alignment, removal, reuse, and oiling. Construct forms using metal of sufficient thickness to ensure that the forms will remain true to shape. Countersink all bolt heads on the face forming the concrete surface. Use clamps, pins, or other connecting devices designed to hold the forms rigidly together and to allow removal without damaging the concrete. Do not use metal forms that do not present a smooth surface or do not line up properly. Keep metal forms free from rust, grease, or other foreign matter.

G. Permanent Steel Bridge Deck Forms

The Contractor may use permanent steel forms to construct bridge deck forms for concrete deck slabs of bridges. Do not use permanent steel bridge deck forms for the overhang portions of the slab.

The following criteria shall govern the design of permanent steel bridge deck forms:

1. Design the steel forms on the basis of dead load of form, reinforcement, and plastic concrete plus 50 pounds per square foot for construction loads. The unit working stress in the steel sheet shall not exceed 0.725 of the specified minimum yield strength of the material furnished, or 36,000 pounds per square inch, whichever is less.

2. Deflection under the weight of the forms, the plastic concrete, and reinforcement shall not exceed 1/180 of the form span or 1/2 inch, whichever is less, but in no case shall this loading be less than 120 pounds per square foot total. The permissible form camber shall be based on the actual dead load condition. Do not use camber to compensate for deflection in excess of

these limits. Laminations may be used to satisfy design criteria.

3. If the design span of the form sheets is less than the clear distance between top girder flanges minus 2 inches, include the design for the support system with the shop drawing submittal.

4. Compute physical design properties according to the American Iron and Steel Institute Specification for the Design of Cold Formed Steel Structural Members, latest published edition.

5. Provide a minimum concrete cover of 1 inch over all reinforcement, both transverse and longitudinal in the bottom mat.

6. Maintain the plan dimensions of both layers of primary deck reinforcement from the top surface of the concrete deck.

7. Do not consider permanent steel bridge deck form as lateral bracing for compression flanges of supporting structural members.

8. Do not use permanent steel bridge deck forms in panels where open longitudinal deck joints are located between stringers.

9. Submit the fabricator's shop and erection drawings to the Engineer of Structures for approval. These drawings shall indicate the grade of steel, the physical and section properties for all permanent steel bridge deck form sheets, and the method of attaching the forms and form supports to the main structural members. All drawings shall be stamped by a Professional Engineer licensed in the State of Tennessee. Review and approval of shop drawings by the Engineer of Structures will extend only to general details of forms and attachments. As this forming system is not an integral load-carrying member of the completed slab, the Engineer of Structures will not review the design. The Contractor shall assume sole responsibility for ensuring the safe design of the metal decking system and its installation.

10. Do not rest form sheets directly on the top of the stringer or floor beam flanges. Securely fasten each flute of each sheet to form supports and to have a minimum bearing length of 1 inch at each end.

11. Place form supports in direct contact with the flange of either the stringers or floor beams. Make all attachments by bolts, clips, or other approved means. Do not weld form supports to main structural members.

12. If permanently exposed form metal contains areas of damaged galvanized coating, thoroughly clean and wire brush such areas, and apply two coats of zinc-oxide powder primer, Federal Specification TT-P-641d, Type II, no color added, to the satisfaction of the Engineer. It is not necessary to touch up minor heat discoloration in areas of welds.

13. Locate transverse construction joints at the bottom of a flute, and field drill 1/4-inch weep holes at not more than 12 inches on center along the line of the joint.

14. Ensure that the concrete is properly vibrated to avoid honeycomb and voids at construction joints, expansion joints, valleys, and ends of form sheets. Obtain the Engineer's approval of pouring sequences, procedures, and mixes. Do not use calcium chloride or other admixtures containing chloride salts in the concrete placed on permanent steel bridge deck forms.

15. After the deck concrete has been in place for a minimum period of 2 days, test the concrete for soundness and bonding of the forms by sounding with a hammer. If this procedure reveals areas of doubtful soundness, remove the forms from such areas for visual inspection after the pour has attained adequate strength.

16. Where sections of the forms are removed, the Engineer will not require the Contractor to replace the forms, but the Contractor shall repair the adjacent metal forms and supports to present a neat appearance and to ensure their satisfactory retention. Remove or repair all unsatisfactory concrete as directed by the Engineer. Repair, at no cost to the

Department, all damage to the concrete, reinforcing steel, or both caused by the inspection process.

17. As permanent steel deck forms are not a structural component of the bridge or deck system, the Contractor shall assume responsibility for determining the structural adequacy of the deck forms to support the wet concrete and specified construction load allowance. It is also the Contractor's responsibility to verify that the deck system meets all the requirements set forth in this section.

18. The Department will not pay for, and will instead consider incidental to the forming system, all overruns in deck concrete attributable to deflections or distortions in the deck form.

H. Special Forming Systems

The use of precast bridge deck panels eliminates the bottom reinforcing mat used in cast-in-place bridge decks; therefore it is not possible to make all of the ties needed to maintain the rigidity of the reinforcing mat, deck form, and girder system. To enhance the stability of this system during construction, provide additional reinforcing, ties, temporary erection diaphragms, and permanent diaphragms as shown on the Plans and as specified below. Include the cost associated with these requirements in the unit price of items bid.

1. Tie the strands projecting from the ends of deck panels to the upper mat of reinforcing steel at 2-foot maximum spacing. Tie the upper mat to projecting shear reinforcement or stud shear connectors at maximum 2-foot spacing along the beam.

2. For precast, prestressed I-beams and bulb-tee beams, construct additional permanent diaphragms or additional temporary erection diaphragms as shown on the Plans between all girders at substructures and at intermediate points such that the spacing between diaphragms does not exceed that shown on the Plans.

3. For precast, prestressed box beams, construct additional permanent diaphragms or additional temporary erection diaphragms as shown on the Plans between all girders at substructures and at intermediate points such that the spacing between diaphragms does not exceed that shown on the Plans.

4. For prestressed I-beams, bulb-tee beams, and box beams, form and pour the bottom 15 inches of diaphragms at bents as soon as possible after setting beams, using Class A concrete (3,000 psi). Pour the remaining portion of the diaphragms at substructures concurrently with the bridge deck. Provide temporary erection diaphragms as shown on the Plans at the ends of girders where the end diaphragms are to be poured concurrently with the bridge deck. The Contractor may also submit alternate temporary diaphragm details to the Engineer for approval.

5. For prestressed beams, do not pour any part of integral abutment backwalls prior to, or concurrently with, placement of the slab until at least half of the slab in the end span has been poured. Pour a minimum of the top 12 inches of the abutment backwall concurrently with the slab. Provide temporary erection diaphragms as shown on the Plans at the ends of girders. The Contractor may also submit alternate temporary diaphragm details to the Engineer for approval. Support the beams to prevent damage due to twisting or overturning during all phases of construction.

6. Place form supports for precast bridge deck panels in direct contact with the flange of the girders or beams. Make all attachments by bolts, clips, or other approved means. Do not weld form supports to the main structural members.

To request use of a special forming system not specifically authorized in this Specification, submit the design and calculations to the Engineer of Structures for review and approval.

I. Global Stability of Exterior Girders during Slab Overhang Pours

Ensure the stability of the exterior girder(s) against twisting, overturning, and web buckling during slab pouring operations. This may require supplemental bracing. When the width of the slab overhang exceeds the depth of the exterior girder, submit details and design calculations for the cantilever support (including deflections caused by the mechanical screed) to the Engineer for approval.

J. Other Considerations

If the deck slab thickness is increased more than 1-1/2 inches due to the use of permanent deck forms or precast deck panels, redesign the girders for the entire change in thickness, and bear all costs incidental to the increased depth of slab thickness and girder redesign, if required.

All bridge beams and girders shall be erected and the grade of the roadway established on the bridge before forming is started for the bridge deck, unless otherwise shown on the Plans or approved by the Engineer.

604.06 Falsework

Support falsework, used to support the forms and concrete for concrete structures, on sills resting on rigid foundations composed of solid rock, piles driven until the bearing capacity of each pile is sufficient to support the required loading, or earth borne footings as specified in this Subsection **604.06**.

The Department will only allow earth borne footings when, in the Engineer's opinion, the soil can adequately support the superimposed loads and the following conditions are met:

1. Only use spread footings on stable ground that is capable of supporting the superimposed load.

2. Grade and maintain the site so as to prevent ponding of water, or erosion of soil in the proximity of the spread footings.

3. Design and construct the falsework system so as not to exceed the bearing capacity of the soil, and in no case to exceed 3,000 pounds per square foot.

4. Design and construct the footings to carry the superimposed loads.

5. Construct all footings on a level plane.

The bearing value of piles will be calculated according to the formulas given in **606.14**.

Design and construct the falsework to support the required loading without distortion or settlement of the forms.

Place "tell-tales" to allow for observation of the amount of falsework settlement at locations designated by the Engineer.

The Engineer may require the Contractor to submit detailed falsework plans, together with a soils report, design calculations, and other information necessary for a thorough review. The Contractor is responsible for the design and construction of the falsework system and shall repair, or remove and replace, as directed and at no cost to the Department, all concrete, other material, or portions of the structure that are damaged or destroyed due to failure of the falsework.

Have all plans for falsework and formwork for cast-in-place structures over navigable waters or pedestrian or vehicular traffic stamped by a Professional Engineer licensed in the State of Tennessee.

Before placing any superstructure concrete, furnish to the Engineer a certification similar to the following:

CERTIFICATION

I hereby certify that the plans for falsework and formwork on (Structure Identification)_____ have been prepared by me in accordance with accepted structural engineering practice. I further certify that said falsework has been erected in full compliance with said plans.

_____, P.E.

Tennessee License Number _____

604.07 Camber

Construct structures of any type or size to a permanent camber only when shown on the Plans. Provide sufficient camber in the falsework and forms for each span to allow for the tightening of joints in the forms and supporting falsework.

604.08 Reinforcement

A. General

All reinforcement shall consist of deformed steel bars meeting the requirements of ASTM A615 Grade 60, unless otherwise shown on the Plans or directed by the Engineer. Use standard CRSI hook details unless otherwise specified. Reinforcing steel designated with the suffix E shall be epoxy coated as specified in **907.01**. Deformed steel bars shall have a net area at all sections equivalent to that of plain round or square bars of the corresponding nominal size.

Steel wire fabric may be furnished in rolls or sheets.

B. Protection of Material

Store reinforcing steel above the ground surface on platforms, skids, or other supports located outside the scope of the active construction operations. Protect the reinforcing steel from physical damage, rust, and other surface deterioration. Remove all brush and weeds from the storage area immediately before storing reinforcing steel in the area.

C. Bending

Cold bend reinforcing steel, where indicated, to the forms and dimensions shown on the Plans. Unless otherwise indicated, ensure that all bends are in one plane. Uncoated bars of 3/4 inch or less that have only hooks or a single bend may be bent in the field, provided satisfactory equipment for proper and accurate work is used, and provided the bending is accomplished true to form and dimensions without damage to the bars. Perform all other bending in the shop before shipment.

D. Substitution

The Contractor may substitute bars of different sizes from those shown on the Plans only with the Engineer's written permission. If substitution is allowed, comply with the following:

1. Do not reduce the total area of steel in any 1 foot in each direction.

2. For cast-in-place concrete, the clear distance between parallel bars in a layer shall not be less than 1.5 bar diameters, 1.5 times the maximum size of the coarse aggregate, or 1-1/2 inches.

3. Where positive or negative reinforcement is placed in two or more layers, place bars in the upper layers directly above those in the bottom layer with the clear distance between layers not less than 1 inch.

4. Clear distance limitation between bars shall also apply to the clear distance between a contact lap splice and adjacent splices or bars. Limit groups of parallel reinforcing bars bundled in contact to act as a unit to four in any one bundle. Limit bars larger than No. 11 to two in any one bundle in beams. Locate bundled bars within stirrups or ties. Individual bars in a bundle cut off within the span of a member shall terminate at different points with at least 40 bar diameters stagger. Where spacing limitations are based on bar diameter, treat a unit of bundled bars as a single bar of a diameter derived from the equivalent total area.

5. In walls and slabs, space the primary flexural reinforcement no farther apart than 1.5 times the wall or slab thickness, or 18 inches.

E. Splicing

Furnish all reinforcement in the full length shown on the Plans, unless otherwise approved in writing by the Engineer. The Contractor may splice temperature reinforcement at no additional cost to the Department. Splicing may occur once per bar in the end sections of box and slab type culverts that are on a skew other than 90 degrees and in box and slab type culverts that require no contraction joints due to their length. In end sections of 90 degree skewed structures and in interior sections of all box and slab type culverts, furnish temperature reinforcement in the full length required, with no splices. Do not make any splices, unless shown on the Plans or authorized by the Engineer of Structures.

Do not splice tension reinforcement at points of maximum stress. Rigidly clamp the members at all splices with at least two approved metal clips located approximately 3 inches from the ends of the bars

and bolted around them, or secure with wire in a manner satisfactory to the Engineer.

Splice steel shapes only as shown on the Plans.

Splice steel fabric by overlapping the sheets by not less than 12 inches, matching at least three transverse members, and by securely wiring the overlapped sections in a manner satisfactory to the Engineer.

F. Placing and Fastening

Before placing reinforcing steel, thoroughly clean it of mill scale, rust, dirt, paint, oil, or other foreign substances or coating of any character that will reduce the bond. Once in-place, if reinforcement becomes dirty, rusty, or spattered with mortar that dries before concrete is placed around it, thoroughly clean such reinforcement, or the part affected, before covering it with concrete.

Accurately place and firmly hold in position all reinforcement as shown on the Plans or as directed by the Engineer. Fasten uncoated steel bars together with metal clips or wire at each intersection. Fasten coated steel bars with coated wire ties or coated clips. Where spacing is less than 1 foot in each direction, fasten alternate intersections. Securely space all reinforcing steel from the forms and between adjacent reinforcement with approved metal spacers, concrete blocks, or other approved devices or methods, except only use metal spacers in slabs of bridges and top slabs of box type structures. Where possible, arrange spacer devices so that their use cannot be detected in the completed structure. Mix concrete for spacer block construction in the same proportions as that used in the concrete mixture. Construct the blocks to be rectangular in shape with uniform surfaces and with no dimension greater than the depth required for proper spacing from the forms or between adjacent reinforcement. Do not use gravel, brick, or wooden blocks.

Before depositing concrete, ensure that all reinforcing steel in the section of the concrete pour is accurately and securely placed and the Engineer has approved the placement. Do not disturb the spacers during concrete placement.

All dimensions relating to the spacing or cover of reinforcing bars are to the centers of the bars or the clear distance respectively, unless

otherwise indicated. Tolerances for placement shall be plus or minus 1/2 inches for spacing and minus 1/8 inch or plus 3/8 inch for cover.

604.09 Drainage and Weep Holes

Construct drainage openings and weep holes using materials in the manner and at the locations shown on the Plans or established by the Engineer. Place ports or vents for equalizing hydrostatic pressure, when required, as directed by the Engineer.

Where structures are to be backfilled, protect weep holes or openings by placing a wire basket, with dimensions of 1 foot x 1 foot x 1 foot and filled with coarse aggregate of size 7, 8, 57, 67, 68, or 78, immediately over or behind the holes or openings, as directed by the Engineer. After all finished grading is complete, clean weep holes of all dirt and debris, and ensure that they are free draining.

604.10 Placing Pipes, Conduits, Anchors, Casting, and other Appurtenances

As directed by the Engineer, place, during construction, all pipes, conduits, anchors, castings, bolts, plates, grillages, and other appurtenances that are necessary or desirable to be placed in the concrete of a structure, whether shown on the Plans or not. Unless otherwise specified, assume that such pipes and conduits will be delivered to the site of the structure by the Department or by other parties for whose use the pipes and conduits are intended.

The Department will not pay for placing such pipes, conduits, and other appurtenances; however, it will not make any deductions for the volume of concrete displaced by those items.

604.11 Handling, Measuring, and Batching Materials

A. Major Structures

Handle, measure, and batch materials to be incorporated in structural concrete as specified in 501.09.

When using lightweight aggregates, uniformly pre-saturate the aggregates by sprinkling and allow to drain. At time of use, ensure that the aggregates are in a saturated surface dry condition to minimize water absorption.

When placing concrete during hot weather, take appropriate measures to reduce the hazards of increased rate of cement hydration and high concrete temperatures.

The temperature of the concrete at point of discharge shall not exceed 90 °F.

Reduce the temperature of the concrete using one or any combination of the following methods:

1. Sprinkle coarse aggregate stockpiles so as to distribute the water evenly and to prevent moisture variation within the stockpile.

2. Use crushed or chipped ice as a portion of the mixing water, or use water cooled by refrigeration or other means. If using ice, substitute it on a pound for pound basis for water and ensure that it is completely melted before the concrete is discharged from the mixer.

3. The Contractor may employ other means as approved by the Engineer.

Unless otherwise specified, to use additives or admixtures, submit a revised mix design for the Engineer's review and approval. Unless specifically provided in the Contract, the Department will consider the furnishing and use of approved additives or admixtures and the other precautions necessary to provide satisfactory concrete and concrete products to be incidental to the furnishing and placement of the concrete, and the Contractor shall bear all additional costs and risks.

Do not mix different types of cement, and do not use them alternately. Where it is necessary for the color of the concrete to be uniform, only those cements that will produce similar color in concrete may be used alternately.

B. Minor Structures

For the following items of construction, the Contractor may substitute a mobile volumetric continuous mixing concrete plant, meeting the requirements of **604.04**, for the method specified in **501.09**.

611 Manholes, catchbasins, inlets, and pipe end walls
701 Cement concrete sidewalks, driveways and median pavement
702 Cement concrete curb, gutter, and combined curb and gutter
703 Cement concrete ditch paving
705 Guard rail
707 Fences
709 Rip-rap slope paving
713 Highway signing
714 Roadway and structure lighting

604.12 Mixing Limitations

Comply with **501.11**.

604.13 Mixing Concrete

Mix concrete as specified in **501.10** for major structures. However, when the concrete is mixed and transported in truck mixers, no more than 90 minutes shall elapse from when the water is added to the mix until the concrete is deposited in place at the site of the work. When the ambient air temperature exceeds 90 °F, no more than 60 minutes shall elapse for concrete placed in bridge decks.

Do not retemper concrete by adding water or by other means. However, the Contractor may withhold a portion of the mixing water or chemical admixtures from transit mixers and add at the work site if all requirements of the approved mix design are met. Water added at the placement site for Class A, Class D, and Class L concrete shall not exceed 1 gallon per cubic yard. The total amount of water in the mix shall not exceed the maximum in the approved mix design. To achieve additional slump, use a water reducing admixture. If water, air entrainers, or chemical admixtures are added at the placement site, mix the concrete a minimum of 30 revolutions at mixing speed after making the additions. Do not use concrete that is not within the specified slump limits, air content limits, temperature limits, or time limits at the time of placement.

For the items of construction identified in **604.11.B**, the Contractor may perform concrete mixing using mobile volumetric measuring and mixing equipment as specified in **604.04**.

When concrete placed in the items of construction specified in **604.11.B** does not exceed 25 cubic yards per week, the Engineer may accept it on the

basis of field testing for air, slump, and occasional strength tests with only random plant inspections as deemed necessary by the Engineer for control.

When the Engineer uses this basis of acceptance, the ready-mix plant furnishing the concrete shall have been inspected and approved for use as specified in **604.04**. In addition, ensure that the delivery ticket accompanying each load of concrete shows the class of concrete, the quantity of cement, aggregates, water, and additives used in the batch, and the time of batching. Ensure that the materials used in the concrete are tested and approved.

604.14 Consistency of Concrete

The slump of the concrete when measured according to AASHTO T 119 shall meet **604.03**.

604.15 Compressive Strength Tests of Concrete

A. General

The Engineer will determine concrete strength by tests performed during the progress of the work, and will use these tests to determine the strength of the concrete for acceptance and pay purposes. The frequency of testing will be as specified in the sampling and testing schedule of the Department's Standard Operating Procedures.

The frequency of testing for compressive strength to determine when forms may be removed, or when a structure may be put into service, will be as requested by the Contractor or as deemed necessary by the Engineer.

B. Concrete Acceptance Cylinders

Make and cure test specimens according to AASHTO T 23, unless otherwise specified or directed by the Engineer. The Department will test the specimens for compressive strength according to AASHTO T 22. Provide the necessary concrete for making test specimens and adequate curing and storage facilities at no additional cost to the Department.

Deliver all acceptance cylinders for testing 28-day strength for conformance with **604.03** to the Central Lab in Nashville, or deliver to the regional lab or other agreed upon pick-up point if arrangements are

made in advance with the Regional Materials Engineer. Concrete cylinders submitted for testing beyond 28 days shall comply with the strength requirements specified in Table 604.15-1.

Table 604.15-1: Strength Requirements

Class of Concrete	Compressive Strength (psi) at:		
	Less than 31 days	**31 to 42 days**	**43 days to 56 days**
A, S	3,000	3,300	3,500
D, L	4,000	4,400	4,600
X	Plans Requirement (Req)	Req. + Req. * (10%)	Req. + Req. * (15%)

If the acceptance cylinders fail to meet the specified strengths, the Contractor may drill core samples from the hardened concrete as verification of concrete strength instead of using the concrete cylinders. The Contractor must provide QC data from companion cylinders that meet or exceed the required strength, and perform a nondestructive test using a Swiss Hammer on the concrete to prove required strength is achieved under the observance of a Materials and Tests Representative. If the above mentioned requirements are met, the Contractor may then elect to drill a maximum of three core samples per set of cylinders from the hardened concrete. The Contractor shall obtain the cores in accordance with the Department's Standard Operating Procedure 4-2, and bear all costs of obtaining the cores and repairing the core holes.

Acceptance for payment may be based on cores provided by the Contractor at its expense. These cores shall meet the strength requirements specified in Table 604.15-1. The Engineer will not accept concrete cylinders and cores submitted for testing beyond 56 days.

The average compressive strength of the two cores taken to represent the low test cylinders will be considered to be the acceptance strength of the in-place concrete, provided that the cores are obtained and tested within 56 days after concrete placement. In accordance with 604.31, the Engineer will accept at reduced pay concrete that meets the required strengths specified in 604.03 for the respective class, but fails to meet the requirements in Table 604.15-1.

All concrete used shall undergo acceptance testing. The Department will determine the method to formally accept in-place concrete that is represented by acceptance cylinders that have been lost, damaged, or destroyed. These methods may include coring or non-destructive testing.

604.16 Placing Concrete

A. General

Do not place concrete until the Engineer has checked and approved forms and reinforcing steel. Ensure that the forms are clean of all debris and are kept wet immediately before concrete is placed. Obtain the Engineer's approval of the method and sequence of placing concrete. Unless otherwise allowed, place all concrete in daylight. Do not start placing concrete in any portion of a structure unless it can be entirely completed in daylight. When the placing of concrete is allowed during other than daylight hours, provide and operate an adequate and approved artificial lighting system. Plans for nighttime operations, including adequate lighting, shall be acceptable to the Engineer.

Use tools of an approved type to thoroughly work concrete during placing operations. The working shall be such as to force all coarse aggregate from the surface and to bring mortar against the forms to produce a smooth finish, substantially free from water and air pockets, or honeycomb.

If the forms show bulging or settlement while concrete is being placed, stop placing until a correction has been made.

Construct T-beam girders, slabs, arch rings, and all horizontal sections, except curbs and sidewalks, monolithically and continuously, unless otherwise allowed by the Engineer.

Construct curbs and sidewalks after the bridge deck is completed, unless otherwise shown on the Plans.

After initial set and before final set of the concrete, do not jar forms or place any strain on the ends of projecting reinforcement. Drive piles no closer than 20 feet to footings that are less than 7 days old and to foundations supporting concrete that is less than 7 days old.

Unless otherwise specified, before placing a bridge deck overlay of Class D or Class L concrete, machine scarify the surface to be covered to a minimum depth of 1 inch. In areas inaccessible to machine scarifying, and in areas of spalling where steel reinforcement is exposed, remove deteriorated concrete using hand tools or other methods approved by the Engineer. After scarifying, clean the deck of all deleterious material. Do not allow traffic on the scarified deck.

Take care to avoid contaminating the surface of the bridge deck after scarification. Remove all contaminants from the deck to the Engineer's satisfaction before placing the concrete overlay.

When placing concrete in bridge decks when the rate of moisture evaporation may be excessive as determined by the Engineer, comply with the following additional requirements.

1. Do not start any concrete deck pours until the mandatory Bridge Deck Construction Pre-pour Meeting is conducted and all pertinent considerations covered by the Pre-Pour Check List are resolved.

2. Protect the concrete to prevent rapid drying due to high temperature, low humidity, high winds, or combinations thereof. Do not place any concrete when the rate of moisture evaporation from the freshly placed concrete exceeds 0.2 pounds per square foot per hour as determined by Figure 604.16-1 below. Provide the Engineer appropriate measuring devices meeting industry standards to establish the temperature of the concrete and ambient air, relative humidity, and wind velocity adjacent to the concrete surface.

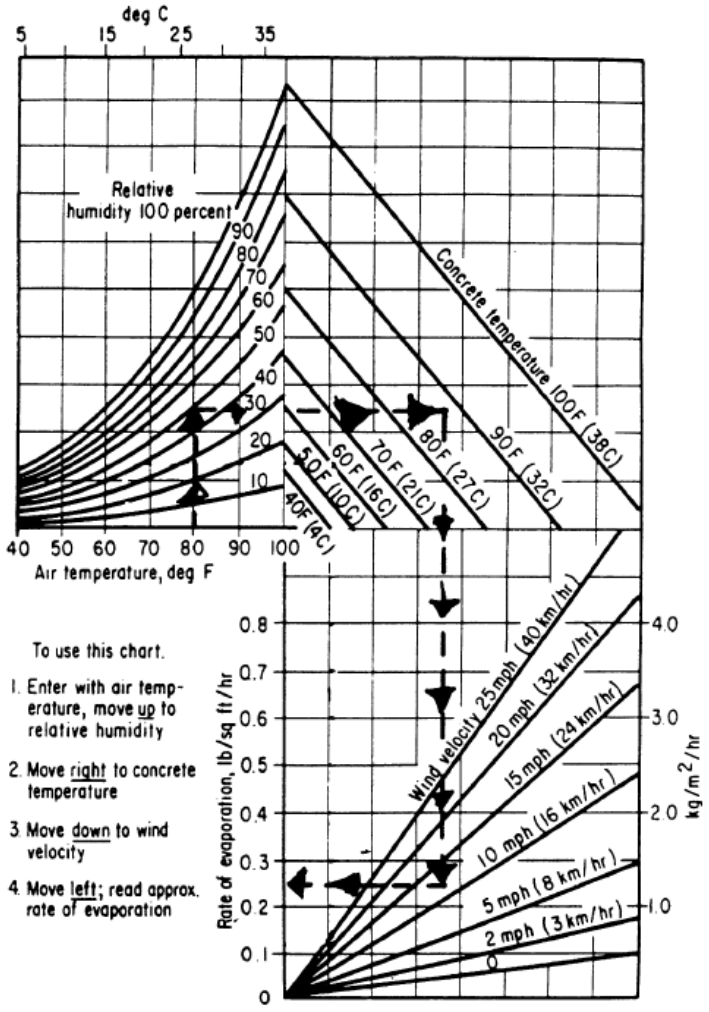


Figure 604.16-1: ACI nomograph for estimating rate of evaporation of surface moisture from concrete

3. If data collected during the 24 hours prior to the pour, or predictions from the National Weather Service indicate that the moisture evaporation rate of 0.2 pounds per square foot per hour may be exceeded, limit concrete placement to hours when the evaporation rate is less than 0.2 pounds per square foot per hour. An exception to this requirement would if the

Contractor demonstrates to the Engineer's satisfaction before the pour that protection can be provided, or other actions taken, to maintain an acceptable moisture evaporation rate. Schedule placement of bridge deck concrete accordingly. Notwithstanding all precautions, if during concrete placement, the evaporation rate of 0.2 pounds per square foot per hour is exceeded, terminate the pour as directed by the Engineer.

In hot weather, apply a certified dry fog with a maximum volume mean diameter (VMD) of 15 microns with a throw distance of 60 feet above the concrete surface during placement and finishing operations. Furnish a certification to the Engineer verifying the VMD.

In addition, immediately before placing the concrete, cool the forms and reinforcing steel to 90 °F or less by using a fine spray of water, leaving no puddles or pockets of water. Sprinkle trucks or keep them in the shade when not being unloaded to help reduce the temperature of the concrete.

Use one of the four following methods at the discharge point when pumping concrete:

1. A metal loop consisting of four 90-degree elbows shall be placed in the line just before the rubber discharge hose.

2. A minimum of 10 feet of line lying horizontally just before the discharge point.

3. A rubber discharge hose configured into a "j" shape or loop, either of which prevents a loss in the pressure of the discharge line.

4. A rubber discharge hose, 10 to 12 feet in length, that reduces in diameter from 5 to 4 inches over its length.

The air content shall meet **604.03** at the point of delivery to the pump.

Use closed chutes or pipes when concrete is to be dumped or dropped for a distance greater than 5 feet. Where steep slopes are required, equip the chutes with baffle boards or use short lengths that will allow the direction of movement to be reversed.

B. Railings and Curbing

When constructing curb, take care in installing railing steel or anchoring devices.

Do not construct concrete railings on any structure until the falsework has been struck.

C. Chutes and Troughs

Place concrete so as to prevent segregation of materials and displacement of reinforcement.

Keep all chutes, troughs, and pipes clean and free from coatings of hardened concrete by thoroughly flushing with water after each run. Discharge the water used for flushing clear of the concrete already in place.

Take care to fill each part of the form by depositing the concrete as near final position as possible. Work the coarse aggregate back from the forms and around the reinforcement without displacing the bars.

D. Vibrating

Unless otherwise directed, compact the concrete with suitable mechanical vibrators operating within the concrete. When required, in addition to vibrating, also hand spade with suitable tools to ensure proper and adequate compaction.

Manipulate vibrators so as to work the concrete thoroughly around the reinforcement and embedded fixtures and into corners and angles of the forms. Do not use vibrators to cause concrete to flow or run into position. The vibration at any point shall be of sufficient duration to accomplish compaction without causing segregation.

Have at least one additional stand-by vibrating unit available for all individual pours in excess of 10 cubic yards.

E. Joints

Do not produce a featheredge at construction joints. Do not construct transverse or longitudinal joints through spans, unless otherwise specified.

Placement of bridge deck concrete between specified transverse construction joints shall be continuous unless otherwise approved in writing by the Engineer. If the Contractor fails to maintain a rate of placement of 20 feet per hour in the longitudinal direction as specified in **604.22**, or if, in the Engineer's judgment, placement is interrupted unduly because of failure or repositioning of equipment or any other cause, the Engineer may direct that all placement be stopped and a transverse construction joint be formed in the deck as shown on the Plans or as directed by the Engineer.

Clean layers completing a day's work, or placed just before temporarily discontinuing operations, of all laitance or other objectionable material as soon as the surface has become sufficiently firm to retain its form.

To construct box culverts 6 feet or less in height, the Contractor may construct the side walls and top slab as a monolith. When using this method of construction, construct any necessary construction joints vertical and at right angles to the axis of the culvert.

To construct box culverts more than 6 feet in height, place the concrete in the walls and allow to set at least 4 hours before constructing the top slab. Leave appropriate keys in the side walls for anchoring the top slabs.

Unless otherwise shown on the Plans, transverse contraction joints in box culverts shall be plain butt joints and longitudinal reinforcement shall not extend across the joint. Space contraction joints at intervals of 30 to 40 feet. Predetermine the location of joints, and when practicable, place them at changes in the box section. Locate these joints parallel to the main reinforcing steel in the slab and not necessarily perpendicular to the axis of the box or slab type culverts.

604.17 Bonding Construction Joints

Where dowels, reinforcing bars, or other adequate ties are not shown on the Plans, form keys of a directed size by constructing projections above the concrete and monolithically with the concrete.

In resuming work, draw the forms tightly against the face of the concrete. Thoroughly clean the entire surface of the concrete to be bonded, and roughen with a steel tool. Before proceeding with concreting, soak the surface with clean water.

604.18 Depositing Concrete Under Water

Do not deposit any concrete, except for cofferdam seals and drilled shafts, under water. Perform the work specified in **204.10** to prepare foundations before placing concrete foundation seals. It is necessary to inspect foundations for seal concrete. Provide an experienced diver equipped with a diving suit, two-way telephonic and other appurtenant equipment necessary for performing underwater inspections.

Place concrete for seals only in still water, and ensure that the cofferdams or cribs meet the requirements specified in **204.09**. Regulate the method of depositing concrete to maintain the surface of the concrete as nearly horizontal as practicable throughout the operation. Place the concrete in a compact mass in its final position using a tremie, unless otherwise approved by the Engineer. Do not disturb the concrete after depositing, and do not expose it to the action of water before final setting.

Obtain cores for each seal footing. However, the Engineer will waive the inspection and coring of the seal footing if the seal footing is founded on piles and the encased piling projects above the seal footing and embeds into the structural footing a minimum length as shown on the Plans.

Obtain four cores, size N, as described by the Diamond Core Drill Association, or larger, representing 80% of the depth of the seal footing as directed by the Engineer unless otherwise noted on the Plans. Should the cores or other inspection indicate an inferior seal, perform corrective measures at no cost to the Department. Unless otherwise noted, consider the costs for coring the seal to be incidental to other work items.

Mix all concrete deposited under water in the proportions designated for Class S concrete. No additional compensation will be allowed for the additional cement. Regulate the consistency of concrete to prevent segregation of material during placement. Place underwater concrete continuously until the work is completed.

The tremie shall consist of a metal tube and suitable hopper of sufficient strength to withstand the stresses to which it is subjected. The tube shall have a minimum inside diameter of not less than 10 inches, and shall be

constructed in sections having flanged couplings fitted with gaskets. Support the tremie so as to allow free movement of the discharge end over the entire top surface of the work and to allow the tremie to be rapidly lowered when necessary to reduce or stop the flow of concrete. Equip the lower or discharge end of the tremie with a suitable valve or device that shall be tightly closed while the tremie is being charged and lowered into position, and that can be fully opened in the lower position. Keep the discharge end closed until the tube is filled with concrete to prevent water from entering. Induce concrete flow by raising the tremie, but always keep the discharge end in the deposited concrete.

After removal of cofferdam sheeting, provide an underwater diver and camera to perform a tactile inspection of the concrete seal exposed faces and provide a video to document the condition of the exposed seal footing surfaces.

604.19 Removal of Forms and Falsework

The Contractor may remove forms for ornamental work, railings, parapets, columns, and vertical surfaces that do not carry loads within 12 to 48 hours, unless otherwise directed by the Engineer. In cold, damp, or freezing weather, all vertical forms shall remain in place until the concrete has set sufficiently to withstand damage when the forms are removed. When removing forms, take care so as not to mar the concrete surface or to subject it to any undue pressure.

Remove or cut, as specified in **604.05.C**, projecting wires or other metal devices used for holding forms in place and that pass through the body of the concrete. Fill the holes or depressions thus made, and all other holes, depressions, and small voids that show upon the removal of the forms, with cement mortar mixed in the same proportions as that used in the body of the concrete being repaired.

The Contractor may release and remove falsework and supports under concrete in structures when:

1. Representative specimens of the concrete, cured by the methods and in the manner of the concrete that the test specimens represent is cured, attain a compressive strength of 3,000 pounds per square inch, and

2. The concrete has been in place a minimum of 7 days, not counting days of 24 hours each in which the temperature falls below 40 °F, or 21 calendar days, whichever occurs first.

After the above conditions have been met, the Contractor may proceed with placing further concrete pours or erecting precast or fabricated members. Allow other loadings as specified in **604.28**.

For continuous concrete girder or slab units, do not release or remove the falsework and supports from any span in the continuous unit until the concrete in all spans has been placed a sufficient length of time to meet all requirements for the removal of falsework and supports specified above.

604.20 Defective Concrete

Remove and replace defective concrete upon discovery. If the surface of the concrete is bulged, uneven or has honeycombing that cannot be repaired satisfactorily, remove and replace the entire section or unit. The extent of the removal shall be as determined by the Engineer.

Concrete having an acceptance compressive strength less than the minimum specified shall be removed, disposed of, and replaced by the Contractor at no cost to the Department, unless specifically authorized by the Engineer, in writing, to be included in the permanent work. Remove and dispose of nonconforming concrete in a manner that will not damage existing construction or other facilities and property.

The Engineer may allow concrete that fails to meet the strength specified to remain in the permanent construction, provided the durability is acceptable; but the Department will pay for this concrete at a reduced price. The Department will adjust the bid price for concrete that fails to meet the specified strength, but is considered structurally adequate for inclusion in the permanent construction, in accordance with **604.31**. The Department will base any downward adjustment in bid price due to low strength concrete on the acceptance compressive strength of record for the concrete, as determined in accordance with **604.15**.

604.21 Finishing Concrete Surfaces

Unless otherwise authorized, finish the surface of the concrete immediately after removing forms.

Give all concrete surfaces a Class I finish.

Give the following surfaces of all structures a Class II or Applied Texture Finish: roadway face and top of curbs, vertical outside face of curb overhang or sidewalks slab, bottom surface of slab overhang, bridge railings, barrier railings, all vertical surfaces of the superstructure of dual bridges exposed to view from either structure, and all surfaces of retaining walls, wing walls, and end walls that are visible from passing vehicles.

Give all surfaces of structures over a highway or another structure exposed to general view a Class II or Applied Texture Finish. Such surfaces, in addition to those specified above, will usually include all parapets, copings, columns, piers, bents, sides and ends of caps, the outside of all fascia beams, the ends of arch rings, outer surfaces of spandrel walls, the exposed surfaces of wing walls, and the faces of abutments. The Plans will show if additional surfaces, other than those already indicated, are to receive a Class II or Applied Texture Finish. If an Applied Texture Finish is used, the color of the finish shall be similar to Mountain Gray, Federal Specification No. 36440, Federal Color Standard 595b, except that the inside face and the top of the parapet or rail shall be White, Federal Specification No. 37886. Submit a color sample to the Engineer for approval.

Do not combine the Class II and Applied Texture Finish. If the Plans show an Applied Texture Finish, do not use a Class II finish.

The Plans may show other finish classes for designated surfaces.

A. Class I, Ordinary Surface Finish

Begin finishing as soon as forms are removed. Remove all fins and irregular projections from surfaces that are to be exposed or waterproofed. On all surfaces, ensure that the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges, and other defects, are thoroughly cleaned, saturated with water, and carefully pointed and trued with a mortar of cement and fine aggregate mixed in the proportions used in the class of the concrete being finished. Mortar used in pointing shall not be more than 30 minutes old. Leave all construction and expansion joints in the completed work carefully tooled and free of all mortar and concrete. Leave the joint filler exposed for its full length with clean and true edges.

On all surfaces that cannot be repaired to the Engineer’s satisfaction, rub as specified for a Class II finish.

B. Class II, Rubbed Finish

Complete a Class I finish as specified in **604.21.A**. Saturate the concrete with water. Ensure that sufficient time has elapsed before the wetting down to allow the mortar used in the pointing to thoroughly set. Rub the surfaces to be finished with a wetted wooden block or a medium coarse carborundum stone. Do not use the carborundum stone until the concrete has hardened to the state where the sand will grind, rather than ravel or roll. Continue rubbing until all form marks, projections, and irregularities have been removed, all voids filled, and a uniform surface has been obtained. Leave the paste produced by this rubbing in place. The Engineer will not allow a brush finish or painting with grout.

After all concrete above the surface being finished has been cast, obtain the final finish by rubbing with a fine carborundum stone and water. Continue this rubbing until the entire surface is of a smooth texture and uniform color.

After the final rubbing is completed and the surface has dried, rub it with burlap to remove loose powder and ensure it is free from all unsound patches, paste, powder, and objectionable marks.

C. Class III, Float Finish

For unformed surfaces, except slab surfaces for pavements or bases, achieve a Class III finish by placing an excess of material in the form and removing or striking off the excess with a template, forcing the coarse aggregate below the mortar surface. Avoid creating concave surfaces. After the concrete has been struck off, thoroughly work the surface and float with a suitable floating-tool of wood, canvas, or cork. Before the finish has set, remove the surface cement film with a fine brush to produce a fine-grained, smooth but sanded texture.

D. Applied Texture Finish

To prepare the surface for a textured finish, first provide a Class 1 Ordinary Surface Finish as specified in **604.21.A.** Allow the concrete to set for a minimum of 28 days to allow for ample cure time and weathering of curing compounds before applying the textured finish. Pressure wash all surfaces just before application. Remove from surfaces to be coated all efflorescence, flaking, coating, rust, dirt, oil, and other foreign substances. Apply coatings only to surfaces that are

free of surface moisture as determined by sight and touch. Shield and mask surfaces that are not to receive a Coated Finish. Vee out cracks over 1/8 inch wide and fill with an approved product from the Department's QPL 13-Section B.5.Structural Materials and Components. Obtain the Engineer's approval of the surface preparation immediately before starting the work.

Apply the textured finish in the number of coats as recommended by the manufacturer and as posted on the Department's Qualified Products List to achieve a total application rate of 1 gallon per 45 square feet. If using a two-coat system, apply a base coat similar in color to Mountain Gray, Federal Specification No. 36440, when the final coat is White, Federal Specification No. 37886. When the final coat is similar in color to Mountain Gray, Federal Specification No. 36440, use a base coat of White, Federal Specification No. 37886. Provide advance notice to the Engineer of the date(s) and time(s) the texture coating is to be applied.

Apply the textured finish with rollers or brushes so as to provide a consistent and uniform coverage. As an alternative, the Contractor may spray the textured finish if using a containment system meeting the Engineer's approval. Regardless of the method of application, prevent drippings and overspray from the texturing process or otherwise contain in a manner that will not contaminate the environment.

Submit to the Engineer certification of the following:

1. Brand name,
2. Production batch or lot number,
3. Qualified Products List Evaluation Number,
4. Manufacturers recommended rate of application,
5. Materials Safety Data Sheet,
6. Materials Data Sheet, and
7. Shipping date.

Submit a color sample to the Engineer for approval.

604.22 Finishing Slab Surfaces for Pavements or Bases

Use approved mechanical finishing machines to finish bridge floors or top slabs of structures serving as finished pavements or bases. In extreme cases where mechanical finishing machines cannot be used, such as narrow

widths due to phase construction, the Engineer may allow hand finishing or other methods.

Mechanical finishing machines shall be approved power driven machines, traveling on rails adjusted to conform to the profile of the roadway. Equip the machines with oscillating or vibrating transverse or longitudinal screeds that may be adjusted to conform to the profile or the required cross-section of the roadway. The screed shall have sufficient strength to retain their shape after adjustment. Pass over each area of the bridge floor with the finishing machine as many times as necessary to obtain the required profile and cross-section.

When using longitudinal screeds, comply with the following restrictions:

1. The span length of the slab section to be poured shall be 70 feet or less.

2. Place sufficient concrete ahead of the strike-off to fully load the beam or girder prior to strike-off.

3. Control the rate of placement to ensure that the concrete will not take its initial set before the entire placement is complete.

4. The slab to be poured shall be in a tangent section.

5. Assume responsibility for damage to the structure caused by using this method. Do not change the sequence of construction, as shown on the Plans, without the Engineer's written approval.

When using the hand method, strike off the bridge floors or slabs with a screed that is parallel to the centerline of the roadway resting on bulkheads or screed strips cut or set to the required cross-section of the roadway. This screed shall have sufficient strength to retain its shape and a cutting edge that may be adjusted to conform to the profile of the roadway. Screeds shall be of sufficient length to finish the full length of spans 40 feet or less in length. Finish spans over 40 feet in length in two or more sections, but no section shall be less than 20 feet in length. Set screed strips or headers to the specified grades, and check and adjust as necessary before the final screeding operation. Work the screed back and forth over the surface until the proper profile and cross-section is obtained.

Maintain a minimum placement rate of 20 feet of deck per hour when placing concrete in a longitudinal direction.

For bases, finish the surface by grooving lightly with a wire broom at an angle of 60 degrees with the centerline. Begin all strokes at the center and end at the edge.

Finish and texture the surface of bridge approach slabs, bridge decks, and top slabs of other structures serving as roadway pavements by Method (3) below, except Method (1) or (2) may be used where shown on the Plans and/or where the design speed of the roadway on which the structure is located is less than 40 miles per hour.

1. Finish the surface by dragging a seamless strip of damp burlap over the full width of the surface. Use a burlap drag consisting of sufficient layers of burlap to slightly groove the surface, and move it forward with a minimum bow of the lead edge. Keep the drag damp, clean, and free of particles of hardened concrete. When allowed by the Engineer, the Contractor may use a light broom or brush herringbone finish that leaves a texture similar to that obtained by the burlap drag.

2. Finish the surface with a burlap drag as noted in (1) above. Then, at an appropriate time during the stiffening of the concrete, form transverse grooves in the surface so that in the hardened concrete the grooves will be between 0.09 and 0.13 inches in width; between 0.12 and 0.19 inches in depth; and spaced at random intervals between 0.3 and 1.0 inches. The grooves shall be relatively smooth and uniform. Form the grooves without tearing the surface or bringing pieces of coarse aggregate to the surface, and to drain transversely.

3. Finish the surface with a burlap drag as noted in (1) above. Then, after allowing the concrete to cure as specified in **604.23** and to harden sufficiently to support the necessary equipment, groove the surface transversely using a mechanical saw device that will leave grooves 0.125 inches wide, 0.125 inches deep, and randomly spaced from 0.75 to 1.125 inches apart center to center. Perform any corrective grinding for smoothness before transverse grinding, otherwise it will be necessary to re-groove.

Establish positive means for removing grooving residue as specified in **604.27.C**.

Terminate the grooves formed by Method (2) or (3) above approximately 12 inches from curbs, parapets, barrier walls, and other vertical walls.

Include all costs for finishing and texturing in the unit price bid for the concrete being placed. As soon as the surface has set sufficiently to withstand damage when walking on it, and not later than the morning following the placing of the concrete, apply a 12-foot straightedge and mark all variations exceeding 1/8 inch. Correct and seal such variations in the same manner as specified in **604.27.C**.

604.23 Curing Concrete

Cure all concrete surfaces as specified below, except those surfaces protected by forms that remain in place 7 days or longer as specified in **604.19**. Use curing materials that meet the requirements of **913**. Begin curing on unformed surfaces immediately after the water sheen disappears and the surface finish is applied. On formed surfaces, begin curing immediately after removing forms.

When the temperature is expected to fall below 35 °F, protect the concrete as specified in **604.24**.

Cure bridge decks and the top slabs of other structures located above the roadway subgrade elevation by using both the Membrane-Forming Compound Method and the Water Method. Use new burlap for each pour, except burlap may be reused on the same project if it is undamaged and deemed acceptable by the Engineer. The Contractor may cure all other concrete surfaces by either of the following methods.

A. Membrane-Forming Compound Method

Give all surfaces the required surface finish, and keep it moist before applying the curing compound. Apply the burlap drag finish on bridge decks, and on the top slabs of other structures that also serve as the roadway surface, as soon as practicable after screeding the surface, and then immediately apply the membrane curing compound.

Apply the curing compound at the manufacturer's recommended rate. Apply the curing compound under pressure. Only use hand sprays in areas that are inaccessible to pressure equipment. At the time of application of the curing compound, the concrete shall be thoroughly moist but without surface water.

At the time of use, ensure that the compound is in a thoroughly mixed condition with the pigment or dye uniformly dispersed throughout the vehicle. If the application of the compound results in a streaked or

blotchy appearance, take corrective action at once to obtain a well-dispersed mixture of uniform appearance. For concrete surfaces that are not protected by burlap curing covers, use other means to protect against marring for a period of 5 days from the date of application. Immediately replace membrane coating marred within the 5-day period on an otherwise unprotected surface.

B. Water Method

As soon as possible after applying curing compound to bridge decks and to other top slabs located above subgrade elevation, apply damp burlap, or other sheet type materials meeting the performance requirements of AASHTO M 171 and approved by the Department, from a work bridge, taking care not to mar the surface of the deck. Immediately cover all other concrete slabs with materials suitable for use with the water cure. After placing the protective cover, immediately apply a mist spray and keep the cover thoroughly wet with a continuously fed soaker hose system for 120 hours.

Keep all surfaces other than slabs protected from the sun and wet for a period of at least 72 hours from the beginning of the initial curing period. For finishing, the Contractor may temporarily remove the covering from curbs, walls, handrails and other surfaces requiring a Class II finish, but shall restore the covering as soon as possible.

604.24 Protection of Concrete in Cold Weather

If, after the concrete has been placed, the ambient temperature is expected to drop below 35 °F, provide insulation blankets, sufficient canvas, and framework, or other types of housing, to enclose and protect the structure in such a way that the air surrounding the fresh concrete can be maintained at a temperature of at least 45 °F and the surface temperature of the concrete will not exceed 80 °F. Maintain the above conditions for a period of 120 hours after the concrete is placed. Furnish a maximum-minimum thermometer to the Engineer for temperature documentation.

604.25 Painting Metals

Paint, as specified in **603**, all exposed surfaces of all metals that are not lubricated or that do not have a bituminous coating, unless otherwise indicated or directed.

Clean the surface of metals having a bituminous coating and treat with two coats of bitumen so as to present a smooth finished surface that is tough and tenacious when cold but not tacky when warm. The bituminous coating shall have no tendency to scale off.

Exposed surfaces, as used above, shall include the inside of cast iron drainpipes or weep holes.

604.26 Waterproofing and Waterstops

Perform waterproofing, where shown on the Plans or directed by the Engineer, as specified in **605**.

Install waterstops, as specified, as shown on the Plans and in conformity with the requirements of these Specifications.

Install waterstops in continuous strips without splices, except that splices will be allowed at changes in direction when necessary to avoid buckling or distortion of the web or flange. Perform all splices of waterstops in accordance with the manufacturer's recommendations. For polyvinylchloride waterstops, the heat used shall be sufficient to melt but not char the plastic.

Ensure that the waterstops are supported during the progress of work and are properly embedded in the concrete. Work the concrete in the vicinity of the joints to ensure maximum density and imperviousness. Use forms that can be removed without damaging the waterstops. Provide suitable guards to protect exposed projecting edges and ends of partially embedded waterstops from mechanical damage.

604.27 Rideability of New or Resurfaced Bridge Decks and Roadway Approaches

A. General

On all highway sections with a design speed greater than 40 miles per hour, the following rideability provisions shall apply to new or resurfaced bridge decks and roadway approaches, except that testing with the Rainhart Profilograph or high speed road profiling equipment need not be performed on bridges with approaches posted for a lower speed due to roadway alignment.

Bridge decks resurfaced with bituminous material shall meet the respective rideability requirements for the bituminous material as specified in **407.18**.

Set all asphalt paving in each 300-foot approach area to grade by using string lines. Set all concrete paving in each 300-foot approach area to grade by using string lines or side forms set to grade. Assume responsibility for the final adjustment of the string lines in the approach area.

Fabricate and install all expansion joints in accordance with the applicable Specifications, Standard Drawings, and approved shop drawings. Form the recess for the expansion device to the proper dimensions to allow placement of the expansion device.

Delay expansion joint installation and temporarily bridge the joint to allow the road profiling and planing equipment to smoothly operate across the joint. Install the expansion device using the proper tools and equipment including grade beams in order to ensure that it is set properly with respect to the roadway surface.

B. Smoothness Testing

After the bridge decks, approach slabs, and roadway pavement tie-ins are completed, the Department will conduct smoothness tests using the Rainhart Profilograph or high speed road profiler output converted to a profile index in each wheel path beginning and ending 300 feet past each end of the bridge unless a shorter distance is specified by the Engineer or shown on the Plans. Where the roadway approaches to the bridge are not paved with hot mix asphalt or Portland cement concrete under this Contract, smoothness testing will be performed only on the bridge deck and approach slabs. Schedule profile testing at least 7 days prior to need. Clean and clear the area to be tested of all obstructions. Wheel paths will be located 3 feet each side of the centerline of each traffic lane.

Each lane for the length of the bridge and approaches (maximum 300 feet beyond each end of the bridge) shall be considered one lot. Using a 0.1-inch blanking band, the pavement roughness index for each lot shall not exceed the maximum allowable Pavement Roughness Index values specified Table 604.27-1.

Table 604.27-1: Pavement Roughness Index
Bridge Profile Index

Lot Distance (feet)	Profile Index Values (inch/mile)
100 to 200	19.5
201 to 300	18.5
301 to 400	18.0
401 to 600	17.5
601 to 800	17.0
801 to 1000	16.5
1001 to 1500	16.0
1501 to 2000	15.5
2001 to 3000	15.0
3001 to 4000	14.5
Over 4001	14.0

In addition, all areas of pavement roughness index using a 0.1-inch blanking band represented by high points having deviations in excess of 0.4 inch for any 25-foot section per each wheel path shall be corrected. All roadway and bridge deck surfaces will be further tested with a 12-foot straightedge and shall meet the requirements of **407.18**, **501.17** and **604.27** as applicable.

C. Corrective Action

For each lot that the pavement roughness index exceeds the maximum allowable value specified in Table 604.27-1, correct the lot area by a method approved by the Engineer. For each 100-foot section of wheel-path that the pavement roughness index exceeds 0.4 inch but is less than 0.5 inch, the Contractor may choose to correct the deficiencies or forfeit the sum of $500.00 per 100-foot section. Correct pavement roughness indexes exceeding those described above or areas failing the straightedge requirements by a method approved by the Engineer.

To perform grinding work, use a power driven, self-propelled grinding machine that is specifically designed to smooth and texture Portland cement concrete surfaces using diamond blades. The effective wheel-

base of the machine shall not be less than 12 feet. The equipment shall be of a size that will cut or plane at least 3 feet wide. The equipment shall be capable of grinding the surface without causing spalls at cracks, joints, or other locations. Only use small grinding equipment for very small areas and only with the approval of the Engineer.

Do not use asphalt milling or cold planing machines to perform grinding work on Portland cement concrete bridge deck surfaces. Do not grind Portland cement concrete bridge deck surfaces within 1-1/2 inches of reinforcing steel.

Perform all corrective action on bridge decks, where practicable, before installing expansion devices and performing final surface grooving. Seal all surfaces that are ground with an approved penetrating sealant listed on the Department's QPL.

Establish positive means for removing grinding and grooving residue. Remove solid residue from pavement surfaces during the grinding or grooving operation. Do not allow residue to flow across lanes used by public traffic or into gutters or drainage facilities. Dispose of residue in a manner that will prevent residue, whether in solid or slurry form, from reaching any waterway in a concentrated state.

The Contractor may allow residue to continuously discharge on adjacent roadway slopes or ditches if the Engineer determines that there is sufficient vegetative cover to adequately filter the residue. However, if the Engineer determines that there is not sufficient vegetative cover on the adjacent roadway slopes and ditches to adequately filter the residue, then collect the residue in approved storage tanks and deposit in settling basins, spread over flat vegetated areas, or filter by other means approved by the Engineer.

The Department will retest corrected surfaces with the profile testing equipment to ensure that the pavement roughness index does not exceed the minimum requirements. Perform corrective action, including grinding of bridge decks and approach slabs, removal of pavement tie-ins, resurfacing, and application of sealants, at no additional cost to the Department.

604.28 Loading and Opening to Traffic

Do not allow any traffic, heavy equipment, storage of materials, or other loading on a structure or any part thereof, except as noted in **604.19**, until

all forms and falsework have been removed as specified in **604.19** and 10 calendar days have elapsed thereafter.

Construction loads on bridges applied anytime subsequent to the placement of girders shall not exceed 50 pounds per square foot based on a uniform distribution of load. Reconcile loads characterized as non-uniform in nature either by analysis equating the load to an effective uniform load or by the use of timbers or other means approved by Engineer to distribute construction loads. The length of load distribution may be taken as the bridge beam spacing (or slab span between walls for concrete culverts) occurring at the location of load application. Submit all analysis and supplementary support details required to ensure proper construction load distribution. If concrete is mounded ahead of the screed machine during placement of the deck, consider that portion extending above the screed elevation as a construction load. Place construction loads as optimally as reasonable to minimize loads on the structure. When the area occupied by construction loads in any structure span exceeds 25% of the area of that span, submit a diagram detailing the location, character, sequence, and weight of all construction loads applied to the structure to the Division of Structures for approval. Submit this diagram at least 30 days in advance of the planned operation.

604.29 Final Cleanup

Perform final cleanup as specified in **104.10**.

COMPENSATION

604.30 Method of Measurement

A. Concrete for Structures

The Department will measure concrete for concrete structures, unless otherwise specified, by the cubic yard for payment purposes. The volume will be computed from the dimensions shown on the Plans or directed in writing by the Engineer, except for the concrete fillet above fabricated bridge girders. This fillet, as shown on the Plans, is intended to allow for adjustment due to the imprecise methods of predicting camber development of structural members. At the time of construction, the fillet actually used to compensate for grade changes due to camber development, super-elevation, or other factors beyond

the Contractor's control will be field measured for payment by profiling of the bridge members.

The Department will make no allowances for:

1. Furnishing the material and constructing drainage openings and weep holes as shown on the Plans or as directed by the Engineer, provided such openings are 6 inches in diameter or less, except that no deduction will be made for such openings in the computation of concrete quantities. Allowance will be made for other openings as indicated.

2. Additional cement used in depositing concrete under water; for use of chemical additives, for fillers, sealers, and tar paper used in expansion joints; for dowels or other materials used in bonding construction joints; for waterstops; and for painting metals.

3. Concrete placed below the foundation elevation shown on the Plans, unless directed by the Engineer. When approved by the Engineer, the Department will measure concrete used for leveling structure footings by the cubic yard using the average end area method or other approved methods.

Unless otherwise indicated, the Department will deduct the volume of concrete displaced by pile heads.

The Department will make no additional compensation for high early strength concrete substituted by the Contractor for other classes of concrete. The unit price for the class of concrete for which the substitution was made shall be full compensation for the concrete.

The Department will measure by the square yard any hydro-blasting of the bridge deck performed before placing a bridge deck overlay.

B. Structure Excavation and Foundation Preparation

The Department will measure and pay for Structure Excavation, Foundation Preparation and Backfill in accordance with **204**, except when the Plans indicate that no payment will be made for excavation and foundation preparation, then the Department will not measure excavation and will consider it incidental to other items of construction.

When, under **204.10.A**, the Contractor places a foundation seal that is not included in the Plans, the Department will not measure and pay for furnishing the concrete and placing the seal, unless the following requirements and conditions are complied with before placing the foundation seal:

1. Cofferdams in which seals are requested shall have been constructed in strict compliance with **204.09**.

2. After investigation, the Engineer determines that conditions have been encountered that make it impracticable to de-water the foundation before placing the footing.

3. The Contractor requests and receives approval for the construction of the seal in writing.

4. The Department and the Contractor execute a Supplemental Agreement to establish a unit price per cubic yard and the method of measurement for the concrete to be used in the seal.

When the above conditions have been met, the Department will measure and pay for the Concrete Foundation Seal in accordance with the terms of the Supplemental Agreement.

C. Reinforcement

The Department will measure and pay for steel bar reinforcement used in concrete structures, unless otherwise specified, by the pound, as computed from the dimensions shown on the Plans, or directed in writing by the Engineer, and the weights specified in Tables 604.30-1 and 604.30-2.

Table 604.30-1: Steel Bar Reinforcement

Bar Designation No.	Weight (pounds per foot)
3	0.376
4	0.668
5	1.043
6	1.502
7	2.044
8	2.670
9	3.400
10	4.303
11	5.313

Table 604.30-2: Large Bar Sizes

Bar Designation No.	Weight (pounds per foot)
14S	7.650
18S	13.600

The bar numbers designate the number of 1/8 of an inch increments in the nominal diameter of the bars. The nominal diameter of a deformed bar is equivalent to the diameter of a plain bar having the same weight per foot as the deformed bar.

The Department will make no allowance for any device for splicing, clamping, tying, or positioning the reinforcement.

D. Applied Texture Finish

The Department will measure Applied Texture Finish by the square yard of concrete surface treated, as determined in accordance with **109**.

604.31 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Class A Concrete (Description)	Cubic Yard
Class D Concrete (Description)	Cubic Yard
Class L Concrete (Description)	Cubic Yard
Class S Concrete (Description)	Cubic Yard
Steel Bar Reinforcement	Pound
Epoxy Coated Reinforcing	Pound
Scarifying	Square Yard
Applied Texture Finish	Square Yard
Hydro-demolition	Square Yard

The Department will pay for the concrete fillet above fabricated bridge girders as bridge deck concrete with the quantities based on the fillet required for a conventional deck forming system and measured as specified in **604.30.A**. The Department will not pay for increases in the fillet depth needed to accommodate the Contractor's chosen deck forming system (e.g. precast deck panels), and will consider this increase to be incidental to other items bid.

The Department will pay for accepted quantities of leveling concrete at 40% of the price bid for the concrete used in the footing.

If the Contractor does not meet the surface rideability requirements specified **604.27**, the Department will make deductions in monies due to the Contractor on a lump sum basis.

When field conditions result in the construction of a different type of box culvert or box bridge from that shown on the Plans (box type to slab type or vice versa), the Department will increase the respective bid price per cubic yard for Class A concrete by 15% for constructing a slab type instead of box type and will decrease the bid price by 13% for constructing box type instead of slab type. The Department will not adjust the Steel Bar Reinforcement unit bid price for the change in box culvert or box bridge type.

Where concrete does not meet the specified strength but is allowed to be included in the permanent construction as specified in **604.20**, or tardy acceptance cylinders or cores fail to meet the strengths specified in **604.15**, the Department will use the following equation to determine percent payment of contract bid price.

$$PP = 100 - (3 \times Ds)$$

Where,

PP = Percent Payment

Ds = Percent Below Specified Strength

$$Ds = \left[\frac{(\text{Specified Strength} - \text{Actual Strength})}{\text{Specified Strength}}\right] \times 100$$

The Department will base the percent payment on the unit price of the item as bid, i.e., volume [cubic yards], length [feet], each, or other designated bid unit. Payment of the calculated percentage includes cost of incidental items such as reinforcing steel when included in the price bid for the item.

Defective concrete greater than 25% below specified strength may remain in place at no cost to the Department if approved by the Department of Structures, or the Contractor may remove and replace the defective concrete.

SECTION 605 – WATERPROOFING

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DESCRIPTION

605.01 Description

This work consists of applying waterproofing materials to Portland cement concrete masonry surfaces.

MATERIALS

605.02 Materials

Provide materials as specified in:

Waterproofing Materials **906**

605.03 Classification

The Department will classify and pay for waterproofing under the following designations:

A. Class I

Waterproofing Class I shall consist of a primer applied cold, followed by four applications of asphalt sealer applied hot, and three layers of bituminized fabric. The primer for asphalt sealer shall also be asphalt. The bitumen for the sealer, including the bitumen in the fabric, shall be all asphalt, as shown on the Plans, and shall be of the type specified or indicated.

B. Class II

Waterproofing Class II shall consist of a prime coat of asphalt applied cold, four seal coats of asphalt applied hot, with three layers of asphalt saturated fabric, and a protection course of asphalt plank. The type of asphalt for seal coats shall be as shown on the Plans or otherwise directed by the Engineer.

605.04 Reserved

CONSTRUCTION REQUIREMENTS

605.05 Preparation of Surface

Before waterproofing any surfaces, give them a Class I finish as specified in **604.21.A**. Immediately before applying the primer, thoroughly clean the surface of the concrete of all dust or other objectionable material. Ensure that the surface of the concrete is dry at the time the primer is applied.

For joints that are essentially open or are free construction joints, but that are not designed to provide for expansion, first caulk and then fill them flush with the surface, as specified.

605.06 Application

A. Class I

Only apply waterproofing in dry weather and when the ambient temperature is above 40 °F. Concrete surfaces shall have cured 10 days for Portland cement concrete and 7 days for high-early-strength concrete.

Only apply waterproofing to surfaces that are thoroughly dry and free from frost.

On inclined or vertical surfaces, begin waterproofing at the lower part of the surface and continue upward. On horizontal surfaces, begin waterproofing at one end, unless otherwise directed by the Engineer, and continue through to the other end.

Spread bitumen, except primer coats, by mopping or brushing on the surface to be waterproofed. The Contractor may spray bitumen for primer coats.

Mopping shall leave the surface completely covered, and where applied on fabric, it shall completely cover each layer so that the weave will be concealed and the layers of the fabric entirely separated.

Spread primer uniformly over the surface at the rate of not less than 0.2 gallons per square yard, and allow it to cure thoroughly before applying the subsequent coats of hot bitumen.

Uniformly apply the hot bitumen coats and coating between fabric. Use at least 0.25 gallons per square yard in each coating or between layers of fabric on horizontal surfaces and at least 0.30 gallons per square yard on vertical surfaces.

Carry all waterproofing material continuously across expansion joints.

For bitumen that is to be applied hot, stir or otherwise agitate it to secure uniform heating and to avoid local overheating.

Allow all surfaces that have been waterproofed with bituminous materials to thoroughly cure before backfilling or placing other material against them.

Apply hot bitumen at temperatures ranging from 250 °F to 325 °F.

Apply the first layer of fabric as follows:

1. At the place of beginning waterproofing, and upon the prime coat, apply hot bitumen to a section 2 inches wider than the strip of fabric to be applied and for the full length of the section.

2. Then roll and press the strip of fabric on this area while the bitumen is hot.

3. On 2 inches of this strip of fabric and an area of the adjoining surface equal to 2 inches wider than a strip of fabric, apply a coating of hot bitumen, and roll and press a strip of fabric, full width, on it, as required for the first strip.

4. Thereafter, lay full widths of fabric as specified for the first strip, and in such manner that each strip will lap the preceding strip by 2 inches. Ensure that side laps are not less than 2 inches and end laps not less than 12 inches.

Apply the second and third layers of fabric in the same manner as the first layer, but ensure that the laps of the layers do not come directly over the laps of either of the other layers. Completely cover the third layer of fabric with a coat of hot bitumen.

When placing on vertical or inclined surfaces, allow the bitumen between two layers of fabric to cool before placing the next layer of fabric.

When placing on horizontal surfaces, the Contractor may apply one layer immediately following the preceding layer, while taking care not to disturb the preceding layer.

Place each strip of fabric without folds or creases, and eliminate all air bubbles and pockets.

B. Class II

Place the asphaltic materials and asphalt saturated fabric for Class II waterproofing as specified above for Class I Waterproofing.

After the final coating of bitumen is applied to the fabric, and while it is hot, place the asphalt plank upon the bitumen and lay tightly, with the end joints broken in each layer of plank. After the planks are laid, fill all open cracks with hot asphalt, and apply hot asphalt to the outer surface of the planks.

The finished surface shall be smooth and true to line and grade.

605.07 Edges

At the edge of all surfaces, or where surfaces are punctured by drains, pipes, or other openings, prevent water from getting between the waterproofing and the surface waterproofed. Construct flashings at curbs and against girders, spandrels, and walls with separate sheets lapping the main sheets not less than 12 inches.

605.08 Protection and Patching

Prevent damage to the materials applied in waterproofing. Repair all damage that occurs by patching. Extend patches at least 12 inches beyond the outermost portion damaged, and extend each succeeding layer at least 3 inches beyond the preceding layer.

Remove and re-lay, or replace as directed by the Engineer, asphalt planks that become damaged.

605.09 Final Cleanup

Perform final cleanup as specified in **104.10**.

COMPENSATION

605.10 Method of Measurement

The Department will measure waterproofing of the various classes by the square yard, based on surface measurements of the area completed and accepted.

The Department will make no deductions for areas not waterproofed of 9 square feet or less within the waterproofing area.

605.11 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Waterproofing, Class I	Square Yard
Waterproofing, Class II	Square Yard

SECTION 606 – PILING

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DESCRIPTION

606.01 Description

This work consists of furnishing and driving or placing piling. This work also includes the furnishing and driving of test piling and production piling and conducting load tests, when shown on the Plans or included in the Contract.

606.02 Classification

The Department will classify piling according to the following designations:

1. Steel "H" Piling, 8, 10, 12, and 14 inches;
2. Steel Pipe Piling, as designated on the Contract Plans;
3. Timber Piling (Untreated), Sizes 1 and 2;
4. Timber Piling (Treated), Sizes 1 and 2;
5. Precast Prestressed Concrete Piling, 14, 16 and 18 inches; and
6. Cast-in-Place Concrete Piling.

Refer to the Plans for the designation and size of piling to be used in the construction.

MATERIALS

606.03 Materials

Provide materials as specified in:

Materials for Concrete	**604.02**
Reinforcement for Concrete Piles	**907.01**
Pre-Stressing Reinforcement Steel and Anchorages	**907.04**
Steel Piles	**908.15**
Steel Shells	**908.16**
Steel Pipes	**908.17**
Paint	**910.03**
Timber Piles	**911.03**

EQUIPMENT

606.04 Equipment

Have all equipment required for handling and driving steel piling, timber piling, precast concrete piling, steel shells or steel pipe on the Project and approved by the Engineer before beginning work.

Use pile driver leads that are straight and allow freedom of movement of the hammer. Hold the leads in position with guys or braces to support the pile during driving. Except where driving piles through water, use leads of

sufficient length to make the use of a follower unnecessary, unless otherwise approved by the Engineer.

Provide equipment and tools to manufacture concrete for piles, whether precast or cast-in-place, which meet **604.04** and the Engineer's approval.

Provide forms for precast concrete piles that meet the applicable requirements of **604.05**.

The plant and equipment furnished for steam and air driven hammers shall have sufficient capacity to maintain, under working conditions, the pressure at the hammer specified by the manufacturer. Equip the boiler or tank with an accurate pressure gauge. Also install a gauge that will accurately measure the pressure at the hammer intake, unless another approved method is provided to furnish the data necessary to determine the energy delivered by the hammer.

Operate diesel hammers with a wide open throttle when blows are being counted to determine the average penetration to use in the safe load formula, except that in the case of diesel hammers with enclosed rams, the throttle settings shall be just short of the settings that would cause non-striking parts of the hammer to rise off the piles as the ram piston travels upward.

Equip diesel hammers that have an enclosed ram with an accurate gauge and charts that will evaluate the equivalent energy actually being produced under any driving condition.

If the Engineer finds the size or type of hammer used to be unsatisfactory, replace it with another size or type of hammer, or use other corrective measures as required to produce satisfactory results.

A. Hammers for Timber Piles

Drive timber piles with an approved steam, air, diesel, or gravity hammer.

1. Steam, air, or diesel hammers shall develop an energy of not less than 6,000 foot-pounds per blow.

2. Gravity hammers shall weigh at least 2,000 pounds and not less than the weight of the driving head and pile. Regulate the

height of fall so as to avoid damage to the pile. The height of fall shall not exceed 20 feet.

B. Hammers for Steel Piles

Drive all steel type piles with an approved steam, air, or diesel hammer. Only use gravity hammers with the Engineer's written approval. If the Engineer approves the use of gravity hammers, meet the requirements specified under paragraph 3 below.

1. Steam, air, or diesel driven hammers shall:

   (a) Develop at least 7,000 foot-pounds of energy.

   (b) Except as provided in paragraph 2(b) below, develop an energy per blow in foot-pounds of not less than 30 multiplied by R, where R is the required minimum bearing resistance of the pile in tons.

   (c) Have a gross energy in foot-pounds of not less than 2.5 times the weight of the pile in pounds.

2. The following additional requirements apply to diesel driven pile hammers:

   (a) Hammers that do not restrict the rebound of the ram shall have a ram weighing at least 2,000 pounds.

   (b) Hammers that have an enclosed ram shall have a rated equivalent energy in foot-pounds of not less than 250 multiplied by R, where R is the required minimum bearing resistance of the pile in tons.

3. When approved by the Engineer, the Contractor may use gravity hammers to drive steel piling provided that:

   (a) The weight of the pile is no more than the weight of the hammer.

   (b) The steel piling will be driven to refusal on rock, and the overburden is relatively free of boulders.

(c) The hammer weighs at least 3,000 pounds and not more than 5,000 pounds. Regulate the height of fall so as to obtain a minimum energy per blow of 12,000 foot-pounds and to avoid damage to the pile. The height of fall shall not exceed 10 feet.

C. Hammers for Precast Concrete Piles

Drive precast concrete piles with a steam, air, or diesel hammer that develops an energy per blow at each full stroke of the piston of at least 12,000 foot-pounds and not less than 1 foot-pound per each pound weight of the pile being driven. Limit the maximum hammer energy such that no damage occurs to the pile during driving.

The following additional requirements also apply to diesel powered pile hammers:

1. Hammers that do not restrict the rebound of the ram shall have a ram weighing not less than 2,750 pounds and not less than 1/4 the weight of the pile.

2. Hammers that have an enclosed ram shall have a rated equivalent energy of at least 15,000 foot-pounds per blow.

D. Hammers for Steel Shells or Steel Pipe

Drive steel shells or steel pipe for cast-in-place piles with hammers that meet **606.04.C**.

CONSTRUCTION REQUIREMENTS

606.05 Preliminary Work

Perform Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, Structure Excavation, Foundation Preparation and Backfill, and Embankment Construction as specified in **201**, **202**, **203**, **204**, and **205**, respectively. In areas where piles are to be driven and excavation or embankment construction is to be performed, complete the excavation or embankment before driving piles.

606.06 Precast Concrete Piles

Construct precast concrete piles as shown on the Plans and according to these Specifications. Construct precast concrete piles of either air-entrained or non-air-entrained Class P concrete that is proportioned and mixed as specified in **615.09**. Submit to the Department for approval a concrete design, indicating the proportions, the source or brand of all materials, and the type of cement to be used. Use a minimum cement content of 658 pounds per cubic yard of concrete. Prepare and place the concrete as specified in **604** with the revisions and additions stipulated herein.

Assemble and place the reinforcement as shown on the Plans.

Stress cables for precast prestressed concrete piles as specified in **615.07** and **615.08**.

Cast piles in a horizontal position. Do not cast in tiers. Place the concrete continuously in each pile and consolidate by mechanically vibrating and spading. Take care to avoid horizontal or diagonal cleavage planes, and to ensure that the reinforcement is properly embedded in the concrete and not displaced. Overfill the forms, screed off the surplus concrete, and finish the top surface to a uniform, even texture similar to that produced by the forms.

Side forms may be removed as soon as their removal will not cause distortion to the hardened concrete. As soon as the forms are removed, repair surface irregularities, and unless otherwise specified, give the piles a Class 1 finish as specified in **604.21.A**.

Cure the precast concrete piles by the water method as specified in **604.23.B**, or by steam curing as specified in **615.11.C.2**

Do not move piles from the bottom supporting forms, or release the stressing force on prestressed piles, until the concrete has attained a compressive strength of at least 3,500 pounds per square inch, as evidenced by test specimens made and cured in the same manner as the piles.

Ensure that the concrete in precast and precast prestressed piles have developed a compressive strength of at least 5,000 pounds per square inch and have reached a minimum age of 7 days before driving the piles.

Make, cure, and perform testing of test specimens as specified in **615.09**.

When handling or hauling precast concrete piles, support them at the points shown on the Plans, or, if not so shown, support the piles at the quarter points. The Engineer will make a final inspection as to condition after delivery to the site.

606.07 Cast-in-Place Concrete Piles

A. General

Construct cast-in-place concrete piles of the design shown on the Plans and that consist of concrete cast in drilled holes or in steel shells or pipes driven to the required bearing. Use Class A concrete meeting **604**. Remove all water from the inside of the drilled holes or the steel shells or pipes before placing the concrete.

B. Drilled Holes

Dry drill all holes for cast-in-place piles to the tip elevations shown on the Plans. The Engineer will examine all holes for straightness and will reject holes that on visual inspection from the top show less than half of the diameter of the hole at the bottom. Provide and place suitable casings when required to prevent caving of the hole before concrete is placed.

After drilling operations have been completed, but before placing concrete, remove all loose material at the bottom of the hole.

Do not use water for drilling operations or for any other purpose that may cause it to enter the hole. Take all necessary action to prevent surface water from entering the hole.

C. Casing

If using casing in drilling operations, remove it from the hole as concrete is placed. Maintain the bottom of the casing not more than 5 feet nor less than 1 foot below the top of the concrete during withdrawal and placing operations, unless otherwise allowed by the Engineer. Prevent separation of the concrete during withdrawal operations by hammering or otherwise vibrating the casing.

D. Steel Shells and Pipes

Inspect the inside of shells and pipes as specified in **606.15**. Remove all loose material before placing concrete. Place the concrete in one continuous operation from tip to cutoff elevation and so as to avoid segregation. Consolidate the concrete in the upper 25 feet of shell or pipe piles by using vibrators.

Do not fill any shell or pipe with concrete until all adjacent shells, pipes, or piles within a radius of 5 feet or 4-1/2 times the average pile diameter, whichever is greater, have been driven to the required resistance.

After a shell or pipe has been filled with concrete, do not drive a shell, pipe, or pile within 20 feet of it until at least 7 days have elapsed.

606.08 Test Piles

When called for in the Bid Schedule, furnish and drive test piles of the dimensions, at the locations, and to the minimum tip elevations, shown on the Plans or as designated by the Engineer.

When approved by the Engineer, the Contractor may drive test piles to be load tested through the existing overburden, without excavating to the bottom of the footing elevation and by predrilling when required by the Engineer, provided that the additional length of test pile necessary to obtain the requirements specified below is furnished at no additional cost to the Department.

Before driving any other test or foundation piles, excavate the ground at each test pile to the elevation of the bottom of the footing.

Drive test piles to be load tested full length or to the specified bearing indicated on the Plans as determined by the applicable specification equation in **606.14**, whichever occurs first. Drive all other test piles full length or to 1.5 times the specified bearing indicated on the Plans, whichever occurs first. However, the tip elevation for all piles shall be either a minimum of 10 feet below ground elevation or the minimum tip elevation when specified on the Plans. If the test pile has been driven to 1.5 times the specified bearing but has not reached the minimum tip elevation, continue to drive the test pile until the required penetration is obtained or practical refusal occurs, whichever occurs first. When the required pile penetration cannot be achieved by driving without exceeding

practical pile refusal, use other penetration aids such as jetting or preformed pile holes. Practical refusal shall be defined as 15 blows per inch for 2 consecutive inches of driving or when 2 times the minimum required bearing is achieved based on the last 6 inches of driving. Use pile driving equipment capable of driving to 1.5 times the specified bearings indicated on the Plans at a driving rate not to exceed 15 blows per inch.

Perform a load test on one or more of the test piles as shown on the Plans or as designated by the Engineer. From driving logs for test piles and hold-down piles, load tests, and other available subsoil information, the Engineer will determine the number and length of piles to be used and the minimum required bearing.

The Engineer may require a test pile to be left in place for use, cut off, spliced, or removed.

Load tests shall consist of a test load accomplished by loading weights on a platform or by jacking against hold-down piles with a suitable apparatus for accurately measuring the test load and the pile settlement under each increment of load. The pile load test apparatus for applying loads and measuring movement shall meet the requirements of ASTM D1143. Apply the load so as not to exert any undue bending stresses or damage to the pile. The loading and calibration system shall be capable of applying and recording loads up to 200% of the pile bearing values shown on the Plans. Materials used in performing load tests shall remain the property of the Contractor. Unless otherwise shown on the Plans, wait a minimum of 3 days between installing the load test pile and starting the test.

The Engineer may direct that load tests be added, deleted, or repeated, and will make payment for such testing in accordance with **606.22**.

The Department based the number of load tests and test piles shown on the Plans on the assumption that the Contractor will drive all tests piles with the same pile driver as was used for the load test pile. If choosing to drive some test piles with a different pile driver, furnish the necessary additional load tests at no additional cost to the Department.

After the Engineer establishes the number and length of piles to be used, the Contractor may drive regular piles with a different pile driver from that used for driving test piles, provided it notifies the Engineer of Structures before pile lengths are established and uses a pile driver that conforms to the specified requirements.

Before driving a pile to be load tested, submit to the Engineer written details outlining the method of applying, measuring, and recording test loads along with sufficient sketches to fully illustrate the method, procedure, and arrangements proposed. For the jacks to be used in the tests, submit to the Engineer calibration certificates from a laboratory approved by the Engineer. Ensure that the certificates are no more than 6 months old.

The following are the two methods for performing pile load tests. Perform the quick load test unless directed otherwise on the Plans.

A. Quick Load Test

The full test load shall be 200% of the pile load shown on the Plans. Apply the load in approximately equal increments of 10 to 20% of the pile load as shown on the Plans, and at intervals of 5 minutes throughout the load test. Take and record readings of time, load, and movement immediately before and after applying each load.

Apply the load until either a plunging failure occurs or the full test load is reached. Plunging failure occurs when continuous jacking is required to maintain the test load. After the final holding time, or immediately after plunging failure occurs, remove the applied load in five approximately equal decrements with intervals of 5 minutes between decrements. Take readings after removing each decrement and 5 minutes after the complete removal of the test load.

B. Maintained Load Test

The full test load shall be 150% of the pile load as shown on the Plans. Apply the test load in maximum increments of 25% of the pile load as shown on the Plans and at time intervals such that the rate of settlement does not exceed 0.12 inch per hour per load increment for a minimum interval of 2 hours. Take and record readings of time, load, and movement immediately before and after applying each load increment.

The failing load is defined as the minimum load that produces one of the following conditions:

1. Rate of settlement exceeding 0.12 inch per hour for a 2-hour period.
2. Settlement occurring during the last 12 hours of the full load test period.
3. Permanent net settlement after rebound in excess of 1/4 inch.

When failure occurs under condition 1, decrease the applied load as necessary until the rate of settlement is within the allowable limits to establish the failing load. Take a final reading 1 hour after complete removal of the load, and accurately record the failing load. The Department will pay the full value of the unit price bid for load tests. The Engineer will decide to what extent, if any, the test pile will be considered as contributing to the support of the structure.

Should failure not occur due to condition 1, carry the load test to completion with the full test load remaining on the pile for 48 hours and then removed in six equal increments at 1-hour intervals with readings taken after the removal of each increment and 1 hour after the complete removal of the test load.

Although the terminology in this Subsection is related to driven piles, it shall also apply to cast-in-place piles if so designated on the Plans.

After performing the load tests shown on the Plans, the Contractor may choose to substitute piling of a different material or configuration from that shown on the Plans provided they meet the minimum design standards and specifications and are approved by the Engineer. The required length of the substituted piling will be determined by additional load test(s) conducted at no cost to the Department. The basis of payment for the piling shall be in accordance with **606.22**, except the total linear feet shall not exceed that established by load tests for the piles shown on the Plans. When additional test piles that are load tested and deemed usable are made at plan location using the substituted material, the Department will make payment at the unit bid price for regular piling.

606.09 Calibration Tests

When diesel or other types of hammers requiring calibration are to be used, calibrate the hammers by performing load tests, as directed by the Engineer, even if no load tests are called for in the Bid Schedule. The Department will not require such calibrations if the hammer is to be used only for driving piles to rock or a fixed tip elevation, or when the hammer is of a type and model that has previously been calibrated by sources acceptable to the Engineer, for similar type, size, and length of pile, and foundation material.

606.10 Order Lists for Piles

The Engineer will furnish the Contractor with an itemized list showing the number and length, as determined by tests, of all required piles, complete in place. The Engineer will not prepare the list of piling for any portion of the foundation area until the required test data representative of that portion has been determined. The Engineer will base the lengths given in the order list on the lengths that are assumed to remain in the completed structure.

Furnish the piles in accordance with the itemized list, except, at no additional cost to the Department, increase the lengths to provide for fresh heading and for such additional length as may be necessary to suit the Contractor's method of operation.

If during pile driving, the conditions encountered require a change in lengths, make such changes by cutting off piling if it is too long, by furnishing new piling, or by splicing as specified in **606.16** if the piling is too short.

The Department will make no allowance for delays caused by the procedure of determining pile lengths.

606.11 Storage and Handling

Store and handle piles so as to avoid damaging them and as follows:

1. Store steel piles above ground, and keep them free of dirt and grease and, insofar as practicable, corrosion.

2. To handle timber piles, do not use hooks, dogs, pike poles, or similar pointed tools, and take care to avoid breaking their surface.

3. Lift precast concrete piles by attaching a suitable bridle or sling to the pile at the points shown on the Plans.

606.12 Driving Piles

Drive piles at the locations shown on the Plans or as directed in writing by the Engineer, and to within an allowed variation as to direction of pile of not more than 1/4 inch per foot of pile length, with a maximum variation at the head of the pile from the position shown on the Plans of not more than 3 inches. To ensure proper positioning of each pile, use templates

constructed of heavy timbers or steel, which are accurately positioned, securely held in place, and approved by the Engineer. When using water jets, ensure that the number of jets and the nozzle volume and pressure is sufficient to erode the material adjacent to the piling freely. The pump shall have sufficient capacity to deliver at all times a pressure of at least 100 pounds per square inch at two 3/4-inch jet nozzles. Before the required penetration is reached, shut off the jets and drive the piles by hammer to final penetration.

When preformed pile holes are used, construct them by drilling or driving and withdrawing a suitable punch or chisel at or near the locations of the piles. If preformed pile holes are so oversized that the sides of a round pile or the corners of a square pile are not in contact with the soil, restore lateral stability by filling the space between the pile and the sides of the hole with approved clean sand, at no cost to the Department. Terminate preformed holes before the required penetration is reached, and drive the pile by hammer to the final tip elevation to seat the pile and secure the minimum required bearing.

Except when the pile head is fitted into a steel head block, provide every timber pile with a metal collar or wire wrapping. Protect the heads of all concrete piles, and the heads of all other piles when the nature of the driving is such that piles may be unduly damaged, with caps of approved design, having a plywood cushion next to the pile head and fitting into a casting, which, in turn, supports a hammer cushion made from durable, manufactured material. Do not use wire rope and other materials of limited durability. Use an approved pile cushion of sufficient thickness to prevent damage to the pile during driving. Use a minimum initial dimension of 4-inch thick plywood pile cushion for concrete piles. Replace the pile cushion before excessive compression (more than 1/2 the original thickness), burning, or charring takes place. During hard driving, several pile cushions may be necessary for a single pile. Use a new pile cushion for each pile.

For special types of piling, provide driving heads, mandrels, or other devices in accordance with the manufacturer's recommendations so that the pile may be driven without damage.

For steel piling, squarely cut the heads and provide a driving cap to align the axis of the pile with the axis of the hammer. When shown on the Plans, cap steel piles with steel plates or other devices.

Use full length piles where practicable. In exceptional circumstances, the Engineer may allow splicing of piles. Splice as specified in **606.16**.

Install production piles full length, except terminate driving when practical refusal as defined in **606.08** has been reached. If production piles do not achieve the minimum required bearing when driven full length, the Engineer will determine if additional piles are required.

The tip elevation for all production piles shall be equal to or below the minimum pile tip elevation shown on the Plans. When the required pile penetration cannot be achieved by driving without exceeding practical refusal, use other penetration aids such as jetting or preformed pile holes.

If piles are raised during driving of other piles, or by any other cause, drive them down again at no cost to the Department.

606.13 Bearing Value and Penetration

When the Bid Schedule provides for load tests, the Engineer will determine the minimum number of hammer blows per unit of pile penetration needed to obtain the specified bearing value based on load tests performed as specified in **606.08** and **606.09**. In the absence of load tests, the Engineer will determine the safe bearing value based on test pile data.

Each driven pile or shell shall have a minimum bearing value as shown on the Plans or as specified by the Engineer given the results of the load test or test pile data. Drive piles with the same driving system (fuel setting, hammer cushion, and pile cushion) as the test piles, or the pile that was load tested.

Piles used to penetrate a very soft upper stratum overlying a hard stratum shall penetrate the hard material a sufficient distance to fix the pile rigidly.

606.14 Determination of Bearing Value

In the absence of load tests, the Engineer will determine the safe bearing value by one of the following formulas:

1. Gravity Hammers:

$$P = \frac{2WH}{S + 1}$$

2. Single Acting Steam or Air Hammers and Diesel Hammers with Unrestricted Rebound:

$$P = \frac{2WH}{S + 0.1}$$

3. Double Acting Steam or Air Hammers:

$$P = \frac{2H(W + Ap)}{S + 0.1}$$

4. Double Acting Steam or Air Hammers and Diesel Hammers Having Enclosed Rams:

$$P = \frac{2E}{S + 0.1}$$

Where:

P	=	Safe load per pile in pounds;
W	=	Weight of the striking part of the hammer in pounds;
A	=	Area of piston in square inches;
p	=	Steam pressure in pounds per square inch at hammer;
H	=	Height of fall in feet for gravity, steam, and air hammers, and observed average height of fall, in feet, of blows used to determine penetration for diesel hammers with unrestricted rebound of ram;
S	=	Average penetration per blow in inches for the last 5 to 10 blows of a gravity hammer or the last 10 to 20 blows of a steam, air, or diesel hammer; and
E	=	Manufacturer's rating for foot-pounds of energy developed by double acting steam or air hammers, and 90% of the average equivalent energy in foot-pounds, as determined by a gauge attached to the pile hammer and recorded during the period when the average penetration per blow is recorded for diesel hammers having enclosed rams. Hammers of this type shall be equipped with a gauge and applicable charts supplied that will evaluate the equivalent energy being produced under any driving condition.

The above formulas are applicable only when:

1. The hammer has a free fall;
2. The head of the pile is free from broomed or crushed wood fiber or other serious impairment;
3. The penetration is at a reasonably quick and uniform rate;
4. There is no appreciable bounce after the blow;
5. The weight of pile is no more than the weight of hammer used, if hammer is of the gravity type; and
6. A follower is not used.

If there is an appreciable bounce, twice the height of bounce will be deducted from H to determine its value in the formula.

The bearing power, as determined by the appropriate formula in the list above, will be considered effective only when it is less than the crushing strength of the pile.

Other recognized formulas for determining pile-bearing power may be used if fully detailed in the Special Provisions.

When the safe bearing value of any pile is found by test or computation to be less than the design load, drive longer piles or additional piles as directed in writing by the Engineer.

606.15 Inspection of Shells for Cast-in-Place Piling

After the shell has been driven, and the core withdrawn, obtain the Engineer's approval of the shell before placing any concrete. Remove and replace shells that have been improperly driven, do not hold their proper form and dimensions, or are broken or otherwise defective.

606.16 Extensions and Splices

A. Steel and Timber Piles

Use full length steel or timber piles where practicable. If splices cannot be avoided, use a method of splicing as shown on the Plans. Spliced piles shall have a full, true, and even bearing at the joint. Do not splice timber piles in abutments.

B. Precast Concrete Piles

Extend precast concrete piles by removing the concrete at the end of the pile and leaving the reinforcement steel exposed for a length of 30 diameters.

Securely brace the pile to prevent it from vibrating during the cutting or building up operation. Remove the concrete to produce a face at right angles to the axis of the pile.

Securely fasten reinforcement similar to that used in the pile to the projecting steel. Place the necessary forms to prevent leakage along the pile.

Immediately before placing concrete, clean the top of the pile of all loose particles, wet it thoroughly, and cover with a thin coating of cement grout. Use Class P or high early strength concrete meeting the applicable requirements of **604** and **615.09**.

Extend precast prestressed concrete piling as shown on the Plans. Use reinforcement similar to that used for precast concrete piling, Size 1.

Remove forms as specified in **604.19**. After the forms have been removed, give the concrete the required finish.

Do not construct caps to be supported by built-up precast concrete piles until test specimens representing the concrete in the buildups attain a compressive strength of at least 3,000 pounds per square inch.

606.17 Cutoffs and Treatment of Pile Heads

Drive or cut the tops of all piles to a true plane at the elevation shown on the Plans, or established by the Engineer.

Saw timber piles that support timber caps to the plane of the superimposed cap, and ensure they fit snugly. Treat untreated timber pile heads as specified in **601.07** before they are to receive caps.

After treatment, place a covering of 20-gauge galvanized iron on each timber pile and fold it down neatly over the side and fasten so as to shed water.

No treatment or covering of pile heads will be required if they are to be encased in concrete.

606.18 Conditioning of Treated Timber Piles after Driving

Thoroughly treat all places where the surface of timber piles is broken as specified in **601.07**. Treat bored holes and holes caused by withdrawing bolts and spikes as specified in **601.06.K**.

606.19 Painting Steel Piles and Steel Shells

Unless otherwise specified, paint steel piles or steel pile shells that extend above the ground or water surface. Extend the paint from 2 feet below the low water or ground surface elevation to the top of the exposed steel. Unless otherwise indicated, use painting System A, as specified in **603.06**, except apply the shop coat in the field. Perform painting as specified in **603**.

606.20 Final Cleanup

After driving and completing the piling, clean the piles of undue discoloration caused by construction operations. Give those areas of concrete piles that will be exposed the applicable finish, as specified in **604.22**.

Perform final cleanup as specified in **104.10**.

COMPENSATION

606.21 Method of Measurement

A. Test Piles

The Department will compute the length of test piles for payment as the total length in linear feet of test piles shown on the Plans or as required by the Engineer; or if the penetration for any one test pile is greater than the length of the pile shown on the Plans or directed by the Engineer, then the linear feet of actual penetration of such test pile will be the linear feet of test pile measured for payment.

Where a buildup or extension is placed on a test pile to be left in place, the Department will compute the actual linear feet of buildup or

extension for payment for the size of pile used as the test pile. The Department will make no allowance for splicing, cutoffs, or cutting off a test pile in order to construct an extension or buildup upon the test pile. No payment will be made for cutting off or removing test piles not to remain in place.

B. Loading Tests

The Department will measure pile loading tests by the unit per each, which will be determined by the number of load tests performed.

C. Piles

The Department will measure piles of the sizes shown on the Plans or as directed by the Engineer, complete in place, including buildups or extensions, by the linear foot. Measurement will not include the part cut off after driving.

Piles spliced, built up, or cut off to such an extent as to change the length of the completed piling from one size to the other size will be computed for payment in the size originally intended.

No measurement for payment will be made for digging or drilling holes, or for jetting piling, to obtain the required penetration.

If, in accordance with **606.08**, the Contractor chooses to substitute piling of a different material or configuration from that shown on the Plans, the total linear feet to be paid will not exceed that established by load tests for the piles shown on the Plans.

D. Splices

The Department will measure splices for timber and steel piles by allowing 3 feet of piling, complete in place, for each splice made, except measurement for payment of splices for steel will be made only for splicing performed within the limits specified in Table 606.21-1.

Table 606.21-1: Payment of Splices for Steel Piles

In-Place Length	Maximum Pay Splices
40 feet or less	None
> 40 feet ≤ 80 feet	1
> 80 feet ≤ 120 feet	2
> 120 feet	3

No allowance will be made for splicing shells or pipe for cast-in-place piling. The Department will not measure splices caused by damage to a pile.

E. Pile Cutoffs

No allowance will be made for cutting off cast-in-place piles.

The Department will measure for payment the actual length of pile cutoff, to the nearest 0.1 foot, for precast concrete, precast prestressed concrete, steel, steel shell, and steel pipe piles.

The Department will not measure for payment steel, steel shell, and steel pipe pile cutoffs having a length of 10 feet or greater. For precast prestressed concrete piles, the 2 feet of piling required for seismic attachment, when the Contractor chooses this option, will not be included in the measurement for cutoff.

Take ownership of unused lengths of piles and pile cutoffs, and remove from the Project. The Department will not measure cutoffs caused by damage to the pile.

606.22 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Test Piles (Description)	Linear Feet
Load Test (Description)	Each
Steel Piles (Size)	Linear Feet
Steel Pipe Piles (Size)	Linear Feet
Untreated Timber Piles (Size)	Linear Feet

Treated Timber Piles (Size)	Linear Feet
Precast Concrete Pile (Size)	Linear Feet
Precast Prestressed Concrete Pile (Size)	Linear Feet
Cast-in-Place Concrete Pile (Size)	Linear Feet
Pile Tips (Description)	Linear Feet

Such payment is full compensation for providing all materials, equipment, labor, and incidentals to complete the work as specified.

The Department will pay for each load test performed as specified in **606.08** at the unit price bid for load tests, except that a load test repeated for any given test pile from the same setup will be paid for at one-half the unit price bid for load tests.

The Department will pay for pile cutoffs at the invoice price of the pile per foot. The Department will not directly pay for the costs of preparing precast prestressed concrete piles for buildups, but will consider this work to be incidental to building up the pile.

The Department will not make additional payment if the Contractor chooses to use high-early-strength concrete.

If test piles and load tests indicate that piling will not be necessary or pile lengths shorter than those shown in the Plans will be acceptable, the price per linear foot for these test piles shall be full compensation for furnishing and removing all equipment for driving piling, and the Department will not compensate the Contractor for any loss or anticipated profits for failure to use piling as shown. If the Engineer directs the use of individual concrete production piling that is longer by more than 16 feet than that shown in the Plans, the Department will pay for that concrete piling at a rate equal to 1.15 times the contract unit price per linear foot for that size concrete pile.

SECTION 607 – PIPE CULVERTS AND STORM SEWERS

607.01 Description 596
607.02 Materials 596
607.03 Equipment 599
607.04 Preliminary Work 600
607.05 Structure Excavation and Foundation Preparation 600
607.06 Laying Pipe Culverts and Storm Sewers 600
607.07 Joining Pipe 601
607.08 Field Strutting 601
607.09 Backfilling 601
607.10 Disposal of Excess or Unsuitable Material 602
607.11 Final Cleanup 602
607.12 Method of Measurement 603
607.13 Basis of Payment 604

DESCRIPTION

607.01 Description

This work consists of constructing pipe culverts, side drains, slope drains, and storm sewers of the kinds and dimensions shown on the Plans or specified in the Contract. The work also includes all labor, materials, and equipment as may be necessary to make connections with other drainage structures as shown on the Plans or as directed by the Engineer.

MATERIALS

607.02 Materials

A. General

Provide materials as specified in:

Joint Mortar **905.02**
Rubber Gaskets **905.03**
Concrete Pipe, Reinforced **914.02**
Polyvinyl Chloride (PVC) Pipe **914.09**
High Density Polyethylene (HDPE) Plastic Pipe **914.10**
CMP Culverts, Pipe Arches, Underdrains **915.02**

Materials for special end connections to pipes or structures, required to complete the work as shown on the Plans or directed by the Engineer, shall conform to **914** and **915**, unless otherwise specified.

Reinforced concrete pipe shall be flat base, round, or oval, as shown on the Plans.

The sizes of pipe shall be identified by the nominal inside diameter. Provide pipe of the sizes and classes or gauges specified in the Contract, shown on the Plans, or established by the Engineer.

For corrugated metal pipe, pipe arches, and underdrains, the Contractor may use either corrugated steel or corrugated aluminum, provided different metals or corrugations are not mixed in a single line of pipe.

Aluminum coated corrugated metal pipe shall conform to the requirements of AASHTO M 274.

Furnish coupling bands and all hardware, except nuts, bolts, and washers, of the same material and coating as the pipe.

When corrugated metal pipe arches are specified as "size equivalent round," the dimensions shall be as shown on the Plans.

B. Pipe Culverts (Cross Drains & Median Drains)

Where Pipe Culverts (Cross Drains & Median Drains) are specified, provide them in accordance with the following:

1. Pipe Diameters from 18 through 60 inches. Provide materials meeting one of the following:

1. Class III, IV, or V concrete pipe meeting either **914.02** or AASHTO M 86.
2. Metal pipe meeting **915.02**.

3. HDPE pipe meeting **914.10**.
4. PVC pipe meeting **914.09**.

2. Pipe Diameters Larger than 36 inches through 48 inches. Provide materials meeting one of the following:

1. Class III, IV, or V concrete pipe meeting **914.02**.
2. Metal pipe meeting **915.02**.
3. HDPE pipe meeting **914.10**.

3. Pipe Diameters Larger than 48 inches. Provide materials meeting one of the following:

1. Class III, IV, or V concrete pipe meeting **914.02**.
2. Metal pipe meeting **915.02**.

C. Pipe Culverts (Side Drains)

Where Pipe Culverts (Side Drains) are specified, provide them in accordance with the following:

1. Pipe Diameters from 18 through 60 inches. Provide materials meeting one of the following:

1. Class III, IV, or V concrete pipe meeting either **914.02** or AASHTO M 86.
2. Metal pipe meeting **915.02**.
3. HDPE pipe meeting **914.10**.
4. PVC pipe meeting **914.09**
5. Steel Reinforced thermoplastic Ribbed Pipe (SRTRP) meeting **914.11**
6. Polypropylene (PP) meeting **914.12**

2. Pipe Diameters Larger than 36 inches. Provide materials meeting one of the following:

1. Class III, IV, or V concrete pipe meeting **914.02**.
2. Metal pipe meeting **915.02**.

D. Pipe Culverts (Storm Drains)

Where Pipe Culverts (Storm Drains) are specified, provide them in accordance with the following:

1. Pipe Diameters 15 through 36 inches. Provide materials meeting one of the following:

1. Class III, IV, or V concrete pipe meeting either **914.02** or AASHTO M 86.
2. HDPE pipe meeting **914.10**.
3. PVC pipe meeting **914.09**.

2. Pipe Diameters Larger than 36 through 48 inches. Provide materials meeting one of the following:

1. Class III, IV, or V concrete pipe meeting **914.02**.
2. HDPE pipe meeting **914.10**.

3. Pipe Diameters Larger than 48 inches. Provide Class III, IV, or V concrete pipe meeting **914.02**.

E. Slope Drains

Where Slope Drains are specified, provide materials in accordance with one of the following:

1. Metal pipe meeting **915.02**.
2. HDPE pipe meeting **914.10**.
3. PVC pipe meeting **914.09**.

EQUIPMENT

607.03 Equipment

Provide hoisting equipment capable of handling and placing the pipe in final position without damaging the pipe. Include mechanical tamps.

CONSTRUCTION REQUIREMENTS

607.04 Preliminary Work

Perform Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction as specified in **201**, **202**, **203**, and **205**, respectively.

607.05 Structure Excavation and Foundation Preparation

Perform Structure Excavation and Foundation Preparation as specified in **204**.

Provide bedding for pipe culverts that conforms to the requirements of **204.10.B** for Class A, Class B, or Class C. If no bedding class is specified, comply with the requirements for Class C bedding. For pipe culverts and storm sewer crossdrains, provide bedding with a longitudinal camber of the magnitude specified by the Engineer.

When excavating to install storm sewers across private property, salvage and replace in its original position, all topsoil and sod disturbed by the excavation operations, unless otherwise specified. Consider all costs of restoring the area to its original condition as incidental to other items of construction.

607.06 Laying Pipe Culverts and Storm Sewers

Lay pipe culverts and storm sewers beginning at the downstream end of the pipe line. Ensure that the lower segment of the pipe is in contact with the shaped bedding throughout its full length. Place bell or groove ends of rigid pipe and outside circumferential laps of flexible pipe facing upstream. Place flexible pipe with longitudinal laps or seams at the sides.

Lay paved invert pipe so that the longitudinal centerline of the paved segment coincides with the flow line. Place vertical oval and elliptically reinforced pipes with the major axis of the reinforcement within 5 degrees of a vertical plane through the longitudinal axis of the pipe.

607.07 Joining Pipe

Rigid pipe may be of bell and spigot or tongue and groove design, unless one type is specified. Join pipe sections so that the ends are fully entered and the inner surfaces are reasonably flush and even.

Use rubber gaskets or other types of joints recommended by the pipe manufacturer and approved by the Engineer.

To form gasket joints, install rubber ring gaskets so as to form a flexible watertight seal.

If the Engineer approves use of other joint types, install or construct them in accordance with the manufacturer's recommendations.

Join metal pipe with approved coupling bands.

HDPE and PVC pipe shall meet the performance requirement for soil-tightness, unless water-tightness is specified. Install joints so that the connection of pipe sections, for a continuous line, will be free from irregularities in the flow line.

Inspect the pipe before placing any backfill, and remove and re-lay or replace pipe found to be out of alignment, unduly settled, or damaged.

607.08 Field Strutting

If required, perform strutting or vertical elongation as shown on the Plans.

Leave ties and struts in place until the embankment is completed, unless otherwise specified.

607.09 Backfilling

After the pipe is installed, backfill the trench as specified in **204** and the Standard Drawings. Visually inspect all pipes during and after installation to ensure conformance to these Specifications. Conduct the final visual inspections for all pipes no sooner than 30 days after completing installation and final fill. Conduct final visual inspections from the inlet and outlet ends of all pipe, providing sufficient hand-held lighting to observe any defects. In addition to visual inspection, perform the testing described below not less than 30 days after completing pipe installation and final fill placement.

Perform all post installation inspections and testing in the presence of Department personnel.

A. High Density Polyethylene Pipe (HDPE Pipe), Polyvinyl Chloride Pipe (PVC), and Corrugated Metal Pipe (CMP)

Conduct a deflection test (mandrel, laser, or manual) on at least 10% of the total number of pipe runs, representing a minimum 10% of the total project footage including a minimum of one run of each pipe size. The Engineer will randomly select installations to be tested to determine whether the internal diameter of the barrel has been reduced more than 5%. If any installation is found to have deflected more than 5%, evaluate all pipe installations for deflection. Provide documentation of station, pipe size, and deflection results to the Engineer.

B. Reinforced Concrete Pipe (RCP)

Visually inspect all RCP for deflection, alignment, cracking, and joint construction during and after installation. Further evaluate installations where visual inspections detect poor construction techniques as directed by the Engineer.

Replace, at no cost to the Department, all pipes with deflections greater than 5% of the nominal pipe diameter, undue misalignment, or poor joint construction. Perform all excavation or additional work including, but not limited to, base stone or asphalt removal and replacement, required to replace a pipe installation due to poor construction techniques at no cost to the Department. Based on visual inspection and deflection testing, the Engineer may request additional inspections at no cost to the Department.

607.10 Disposal of Excess or Unsuitable Material

Dispose of excess or unsuitable excavated material as directed by the Engineer. Use excavated material as specified in **204.08.C**.

607.11 Final Cleanup

Perform final cleanup as specified in **104.10**.

COMPENSATION

607.12 Method of Measurement

A. Concrete Pipe Culverts and Concrete Storm Sewers

The Department will measure concrete pipe culverts and concrete storm sewers of the different classes, shapes, and sizes specified, by the linear foot of pipe installed and accepted. The Department will pay for the quantity of pipe cut off, not to exceed 2 feet, at the contract bid price for pipe in place.

B. Corrugated Metal Pipe and Corrugated Metal Structural Plate

The Department will measure corrugated metal pipe and corrugated metal structural plate pipe by the linear foot of pipe installed and accepted. The Department will make measurements as follows:

1. Metal pipe and metal structural plate pipe, with square and vertical ends or with skewed and vertical ends will be measured, in place, end to end of the metal on the centerline of the structure.

2. Metal pipe and metal structural plate pipe, with square ends beveled, and with ends skewed and beveled, except arch pipe, will be measured, in place, by averaging the end-to-end distances at the top and bottom of the pipe, measured parallel to the centerline of the structure.

3. Metal arch pipe and metal structural plate arch pipe with square ends beveled, and with ends skewed and beveled, will be measured, in place, end to end of the metal along the invert of the structure.

C. HDPE Pipe and PVC Pipe

The Department will measure HDPE pipe and PVC pipe by the linear foot of pipe installed and accepted. The quantity of pipe cut off, not to exceed 2 feet, will be paid for at the contract bid price for pipe in place.

D. Slope Drains

The Department will measure Slope Drains in the same manner as specified for corrugated metal pipe in **607.12.B**.

E. Pipe Culverts (Side Drains)

The Department will measure Pipe Culverts (Side Drains) of the different sizes specified by the linear foot along the centerline of the installed pipe, not to exceed the ordered length of the pipe. Order Pipe Culverts (Side Drains) in increments of 2 feet.

F. Incidentals

Unless otherwise shown on the Plans, the Department will not measure structure excavation, and will consider such work incidental to other items of construction. When the Plans provide for direct payment for structure excavation, the Department will make measurement and payment in accordance with **204**.

The Department will not pay for labor and materials used in making branch connections. The length of pipe in the branch connection will be measured and included in the quantity of pipe installed in the branch line.

The Department will not separately measure strutting of corrugated metal pipe and corrugated metal structural plate pipe, but will consider such costs as included in the unit price bid per linear foot of pipe.

607.13 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
__" (Type) Pipe Culvert (Description)	Linear Feet
(Type) Pipe Arch (Size)	Linear Feet
__" Slope Drain Pipe	Linear Feet
__" Crossdrain Pipe Culvert	Linear Feet
Box Culvert (Size)	Linear Feet
__" Slotted Drain Pipe	Linear Feet

Such payment is full compensation for all labor and materials used in making joints and connections to other structures; for strutting, when required; excavation, bedding, and backfill, unless otherwise provided for in the Contract, and for completing all incidentals necessary to complete the item.

SECTION 608 – SANITARY SEWERS

608.01 Description 606
608.02 Materials 606
608.03 Equipment 607
608.04 Preliminary Work 607
608.05 Structure Excavation and Foundation Preparation 607
608.06 Laying Pipe 607
608.07 Constructing Joints 608
608.08 Connections 608
608.09 Test for Watertightness 609
608.10 Backfilling 609
608.11 Method of Measurement 609
608.12 Basis of Payment 610

DESCRIPTION

608.01 Description

This work consists of constructing sanitary sewers, or parts of sewers, composed of the kinds and dimensions of pipe shown on the Plans or established by the Engineer. The work also includes such incidentals, materials, and labor as may be necessary to make connections with other structures, as shown on the Plans or as directed by the Engineer.

MATERIALS

608.02 Materials

Provide materials as specified in:

Joint Mortar **905.02**
Rubber Gaskets **905.03**
Hemp or Oakum Gaskets **905.04**
Concrete Pipe, Non-Reinforced **914.01**

Concrete Pipe, Reinforced **914.02**
Vitrified Clay Pipe **914.06**
Polyvinyl Chloride (PVC) Pipe **914.09**
Cast Iron Pipe **915.01**

EQUIPMENT

608.03 Equipment

Provide equipment as specified in **607.03**.

CONSTRUCTION REQUIREMENTS

608.04 Preliminary Work

Perform Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction as specified in **201**, **202**, **203**, and **205**.

608.05 Structure Excavation and Foundation Preparation

Perform Structure Excavation and Foundation Preparation as specified for pipe culverts in **204**.

Provide bedding for sanitary sewers that conforms to the requirements of **204.10.B** for Class A, Class B, or Class C. If no bedding class is specified, comply with the requirements for Class C bedding.

608.06 Laying Pipe

If new facilities or other construction interfere with the existing flow of sewage, provide satisfactory by-pass facilities. Do not divert sewage into an open ditch at any time. Unless otherwise specified, the Department will not directly pay for the costs incurred in providing by-pass facilities, but will consider this work to be incidental to other items of construction.

Lay pipe without break in grade from structure to structure and with the bell or groove end upgrade. Ensure that each section has firm bearing throughout its length and forms a close concentric joint with the adjoining pipe. Make junctions and turns with standard or special fittings.

Do not allow water to run or stand in the trench while pipe laying is in progress, before the joint has completely set, or before the trench has been backfilled. Do not open up more trench at any time than the available pumping facilities are able to dewater.

If the work ceases for any reason, securely close the end of the pipe with a tight fitting plug or cover. For all branch openings or service connections provided for future use, securely close with a tight fitting plug and seal to prevent leakage. Plug open ends of pipe to be abandoned, and seal in a manner approved by the Engineer.

When the pipe connects with structures, place or cut off the exposed ends to be flush with the interior face of the structure and make satisfactory connections.

Take up and relay, at no cost to the Department, pipe that is not in good alignment, shows undue settlement, or is damaged.

608.07 Constructing Joints

Lay pipe and seal joints in a continuous operation. Seal all joints during the same day in which the sections of pipe are laid. Construct the joints to be watertight, using a method of connection that meets the Engineer's approval.

Clean the joints of cast iron pipe, and then joint and seal with materials recommended by the pipe manufacturer.

Make joints in concrete or clay pipe with hemp or oakum gaskets impregnated with hot asphalt and sealed with hot poured sewer joint sealing compound, hemp or oakum gaskets impregnated with neat cement grout and sealed with mortar, rubber gaskets, mastic compound, or other elastic material, or other types of joint recommended by the pipe manufacturer.

As the work progresses, clean the interior of all pipe in place.

608.08 Connections

Make connections by constructing manholes or other structures or installing wyes or tees as shown on the Plans or directed by the Engineer. Install wyes and tees for future connections as shown or directed.

Make connections to existing structures and sanitary sewer house service connections as shown on the Plans or directed by the Engineer.

Include the cost of temporary connections and disinfecting and deodorizing excavation or sewage in the unit price bid for other items of construction.

608.09 Test for Watertightness

When required, perform tests for watertightness at no cost to the Department. Conduct the tests in the presence of the Engineer and in accordance with the established procedures prescribed by the local municipality, utility, or owner.

Rebuild or repair, as required and at no cost to the Department, all sanitary sewers and connections showing leakage in excess of that allowed by the local codes or established regulations. The Engineer will only accept rebuilt or repaired sewers that pass the above test.

608.10 Backfilling

After the pipe is installed, backfill the trench as specified in **204**.

COMPENSATION

608.11 Method of Measurement

The Department will measure pipe for sanitary sewers, of the various kinds, types and sizes, by the linear foot of pipe installed and accepted. The length will be determined by measuring along the centerline of the pipe from center to center of structures, or junction fittings. An allowance of 2 feet of the kind and size of pipe in the sewer line will be made for each wye or tee required in the line. The Department will measure each kind, type, and size, determined by the nominal inside diameter of the pipe, separately.

The Department will measure sanitary sewer house service connections per each.

The Department will not directly pay for the labor and materials used in making branch connections, and will consider this incidental to the work.

Unless otherwise shown on the Plans, the Department will not measure structure excavation, and will consider such work to be incidental to other

items of construction. When the Plans provide for direct payment for Structure Excavation, the Department will measure and pay for this work in accordance with **204**.

608.12 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
__" Sanitary Sewer Pipe	Linear Feet
Sanitary Sewer House Service Connections	Each

Such payment is full compensation for all labor, materials, and incidentals necessary to complete the items.

SECTION 609 – PIPE REMOVED AND RELAID

609.01 Description 611
609.02 Materials 611
609.03 Equipment 612
609.04 Preliminary Work 612
609.05 Removing Pipe 612
609.06 Preparing Pipe for Relaying 612
609.07 Structure Excavation and Foundation Preparation 613
609.08 Relaying or Placing Pipe 613
609.09 Backfilling 613
609.10 Final Cleanup 613
609.11 Method of Measurement 613
609.12 Basis of Payment 614

DESCRIPTION

609.01 Description

This work consists of removing and relaying pipe culverts and storm sewers or sanitary sewers as shown on the Plans, specified in the Contract, or directed by the Engineer. The work also includes all labor and materials as may be necessary to make connections with other drainage structures as shown on the Plans or as directed by the Engineer.

This item does not include pipes that are to be removed but not to be incorporated into the Work.

MATERIALS

609.02 Materials

Provide materials as specified in:

Joint Mortar **905.02**

Rubber Gaskets **905.03**
Hemp or Oakum Gaskets **905.04**

Obtain the Engineer's approval of all materials and devices to be used in making connections before using them in the work.

EQUIPMENT

609.03 Equipment

Provide equipment as specified in **607.03**.

CONSTRUCTION REQUIREMENTS

609.04 Preliminary Work

Perform Clearing and Grubbing, Removal of Structures and Obstructions, and Excavation and Undercutting as specified in **201**, **202**, and **203**, respectively.

609.05 Removing Pipe

Carefully remove the pipe and handle so as not to damage or cause the pipe to be unfit for relaying.

Replace pipe damaged as a result of negligence or inefficient handling or any other action under the Contractor's control, with pipe of the same kind and quality at no cost to the Department.

609.06 Preparing Pipe for Relaying

Clean the pipe, inside and outside, of all dirt, debris, mortar, and other foreign matter.

Cut salvaged pipe to obtain the required lengths, and furnish coupling bands, gaskets, and other jointing materials necessary to make all connections.

Ensure that all pipe to be relaid is sound and in good condition. Do not use broken or deteriorated sections of pipe or connections.

609.07 Structure Excavation and Foundation Preparation

Perform Structure Excavation and Foundation Preparation as specified in **607.05**.

609.08 Relaying or Placing Pipe

Relay or place pipe of the various types specified as prescribed for the respective types in **607.06**, **607.07**, **607.08**, **608.06**, and **608.07**.

609.09 Backfilling

Perform backfilling as specified in **204** for pipe culverts.

609.10 Final Cleanup

Dispose of all excess or unsuitable material as directed by the Engineer.

Perform final cleanup as specified in **104.10**.

Store all material that is to become the Department's property as directed by the Engineer.

COMPENSATION

609.11 Method of Measurement

The Department will measure pipe removed and relaid, of the various kinds, by the linear foot along the center-line of the pipe and from end to end of the pipe, complete in place, including incidentals, after relaying.

The Department will not measure pipe removed but not relaid. Excavation, including the volume occupied by the pipe, performed to remove pipe under this Section will be measured for payment in accordance with **204.12**, for Culvert Excavation (Unclassified).

Unless otherwise shown on the Plans, the Department will not measure structure excavation, and will consider such work to be incidental to other items of construction. When the Plans provide for direct payment of Structure Excavation, the Department will measure and pay for this work in accordance with **204.12** for Culvert Excavation (Unclassified), and the

volume occupied by the pipe will be included in the measurement for payment.

609.12 Basis of Payment

The Department will pay for accepted quantities of pipe removed and relaid at the contract unit price per linear foot for each type of pipe, complete in place.

With the exception of pipe to be replaced at the Contractor's expense, the Department will pay for pipe used to replace rejected pipe under the Section covering the type and kind of pipe being replaced.

SECTION 610 – PIPE DRAINS

610.01 Description 615
610.02 Materials 615
610.03 Reserved 616
610.04 Preliminary Work 616
610.05 Structure Excavation and Foundation Preparation 616
610.06 Backfill 616
610.07 Suspending Pipe Drains 616
610.08 Placing and Joining Pipe 617
610.09 Painting Pipe Drains 617
610.10 Finishing and Final Cleanup 617
610.11 Method of Measurement 617
610.12 Basis of Payment 618

DESCRIPTION

610.01 Description

This work consists of furnishing and constructing or placing pipe drains not classified as pipe culverts or storm sewers in **607**, sanitary sewers in **608**, or underdrains in **710**. Construct pipe drains of the kinds and sizes of pipe shown on the Plans, specified in the Contract, or established by the Engineer.

MATERIALS

610.02 Materials

Provide materials as specified in:

Joint Mortar **905.02**
Rubber Gaskets **905.03**
Paint **910**
Non-Reinforced Concrete Pipe **914.01**

Vitrified Clay Pipe **914.06**
Plastic and Polyethylene Corrugated Tubing **914.07**
Cast Iron Pipe **915.01**
Corrugated Metal Pipe (Non-Perforated) **915.02**
Corrugated Aluminum Pipe (Non-Perforated) **915.02**

Use the paint system shown on the Plans.

Where Pipe Drains (Bridge Drains) are specified, provide metal pipe meeting **915.02**, or polyethylene pipe meeting AASHTO M 294.

610.03 Reserved

CONSTRUCTION REQUIREMENTS

610.04 Preliminary Work

Perform Clearing and Grubbing, Removal of Structures and Obstructions, and Excavation and Undercutting as specified in **201**, **202**, and **203**, respectively.

610.05 Structure Excavation and Foundation Preparation

Perform Structure Excavation and Foundation Preparation as specified in **204**.

For pipe drains, unless otherwise shown on the Plans or directed by the Engineer, provide Class C bedding as specified in **204.10.B**.

610.06 Backfill

Backfill trenches as specified in **204** for pipe culverts.

610.07 Suspending Pipe Drains

Where pipe drains are to be placed above the ground surface, suspend them as shown on the Plans or as directed by the Engineer, and ensure that they are securely and rigidly held in place.

610.08 Placing and Joining Pipe

Place pipe for drains as specified in **607.06**. Make joints in concrete, clay, and corrugated metal drain pipe as specified in **607.07**.

Form joints in cast iron pipe in accordance with the manufacturer's recommendations, using the recommended fittings and methods.

610.09 Painting Pipe Drains

Do not paint concrete, vitrified clay, and corrugated metal pipe drains, even if they are to be exposed, unless otherwise shown on the Plans.

Paint cast iron drains that are to be exposed and do not have a bituminous coating in accordance with the applicable requirements of **603**. Clean cast iron pipe drains that have a bituminous coating, and treat with two coats of bituminous material of such kind and grade that the finished coating will be tough when cold and not tacky during hot weather.

Painting shall include all hangers, braces, and other appurtenances.

610.10 Finishing and Final Cleanup

Dispose of all excess or unsuitable material as directed by the Engineer.

Perform final cleanup as specified in **104.10**.

COMPENSATION

610.11 Method of Measurement

The Department will measure pipe drains, of the various kinds and diameters, for payment by the linear foot along the centerline of the pipe, and from end to end of the pipe, including incidentals, complete in place. The Department will measure each kind and diameter of pipe separately.

The Department will not measure excavation, foundation preparation, or backfilling associated with the construction of pipe drains for payment.

The Department will not measure hangers, braces, and similar supports for suspending or hanging pipe drains.

Pipe used in weep holes and drainage openings 6 inches in diameter or less, through concrete abutments, decks, slabs, floors, walls, or similar features will not be paid for directly or under the pay items of this Section, but will be handled in accordance with **604.30.A.**

610.12 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
__" Pipe Drain (Bridge Drain)	Linear Feet
Plastic Pipe Drains (__")	Linear Feet

SECTION 611 – MANHOLES, CATCHBASINS, INLETS, AND PIPE END WALLS

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DESCRIPTION

611.01 Description

This work consists of constructing manholes, catchbasins, inlets, and pipe end walls at the locations shown on the Plans. The work includes furnishing and installing incidental appurtenances and connections to pipe and other structures as may be necessary to complete the construction as shown on the Plans or as directed by the Engineer.

MATERIALS

611.02 Materials

Provide materials as specified in:

Steel Bar Reinforcement **907.01**
Structural Steel **908.01**

Gray Iron Castings **908.07**
Precast Manholes and Catch Basins..... **921.10**
Manhole Steps..... **921.11**

For cast-in-place Portland cement concrete, use Class A concrete. Manufacture, place, and cure structural concrete as specified in **604**.

Use bolts, anchors, frames, and hangers for castings and plates as approved by the Engineer.

The Contractor may use either the manhole and catch basin sections detailed on the Plans or may substitute comparable sections of cast-in-place concrete or precast reinforced concrete, as may be applicable. When a substitution is proposed for a manhole or catch basin section detailed on the Plans, construct the substitute section in accordance with the applicable Standard Drawing as approved by the Engineer. If the Department has no Standard Drawing of the substitute section, submit shop drawings of the revised section to the Engineer for approval prior to construction. After obtaining the necessary approval, furnish the Engineer an electronic CADD file or a permanent, 4-mil mylar reproducible of the design.

611.03 Reserved

CONSTRUCTION REQUIREMENTS

611.04 Preliminary Work

Perform Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction as specified in **201**, **202**, **203**, and **205**, respectively.

611.05 Structure Excavation, Foundation Preparation, and Backfill

Perform Structure Excavation, Foundation Preparation, and Backfill as specified in **204**. Do not backfill or allow traffic on cast-in-place sections until 7 calendar days after the representative test specimens reached the required compressive strength.

611.06 Concrete Construction

Perform all concrete construction as specified in **604**.

611.07 Inverts

Construct inverts of Class A concrete to conform to the shapes shown on the Plans and so as to cause the least possible resistance to flow. The shape of the inverts shall conform uniformly to inlet and outlet pipes. Provide a smooth and uniform finish.

611.08 Brick Construction

If a precast or cast-in-place catch basin cannot be used, the Contractor may use brick catch basins following consultation with the Standards and Policy Office of the Roadway Design Division. If approved, perform all brick construction as specified in **613**.

611.09 Inlet and Outlet Pipes

Extend inlet and outlet pipes through the walls of manholes, catchbasins, and inlets for a sufficient distance beyond the outside surface to allow for connections, but cut the pipes off flush with the wall on the inside surface, unless otherwise directed.

Construct the concrete or brick and mortar around the pipes so as to prevent leakage and to form a neat connection.

611.10 Castings and Fittings

Handle castings and fittings in a manner that will prevent damage. The Engineer will reject damaged castings and fittings.

Place all castings and fittings in the positions shown on the Plans or as directed by the Engineer, and set true to line and grade.

If castings are to be set in concrete or cement mortar, place all anchors or bolts in position before placing the concrete or mortar. Ensure that the casting will not be disturbed until the mortar or concrete has set.

When castings are to be placed upon previously constructed masonry, bring the bearing surface of masonry true to line and grade so as to present an even bearing surface that will allow the entire face or back of the casting to come in contact with the masonry. Set castings in mortar beds or anchor to the masonry as shown on the Plans or as directed by the Engineer.

Set castings to be firm and snug and to not rattle.

611.11 Final Cleanup

Dispose of all excess or unsuitable material as directed by the Engineer.

Perform final cleanup as specified in **104.10**.

COMPENSATION

611.12 Method of Measurement

A. Manholes, Catchbasins, and Inlets

When the Bid Schedule indicates that manholes, catchbasins, and inlets will be measured by the unit (per each), the Department will measure as follows:

1. Manholes will be measured by the unit, per each, for the various types, diameters, and ranges of depth as shown on the Plans.

2. Catchbasins will be measured by the unit, per each, for the various types and ranges of depth as shown on the Plans.

3. Inlets will be measured by the unit, per each, for the various types shown on the Plans.

B. Components of Manholes, Catchbasins, Inlets, and End Walls

When the Bid Schedule contains items for various components of manholes, catchbasins, inlets, and end walls, the Department will measure as follows:

1. Portland cement concrete and steel bar reinforcement will be measured in accordance with **604.30**.

2. Structural steel and gray iron castings will be measured by the computed weight based on the dimensions shown on the Plans and deducting for open holes. To this weight the Department will add 5% allowance for fillets and overruns. The Department may substitute scale weights for computed

weights of small complex parts for which accurate computations would be difficult.

3. Steps will not be measured and paid for directly, but will be considered incidental to the pay items of other materials with which the structure is constructed.

4. Unless otherwise shown on the Plans, the Department will not measure structure excavation and will consider it incidental to other items of construction. When the Plans provide for direct payment for Structure Excavation, the Department will measure and pay in accordance with **204**.

611.13 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Manholes __′ to __′ Depth	Each
Junction Box (Description)	Each
Catch Basins, Type __, __′ to __′ Depth	Each
Spring Drain Box (Description)	Each
Bridge Edge Drain (Size)	Each

Such payment is full compensation for furnishing all materials, equipment, tools, labor, and incidentals necessary to complete the item.

When the Contractor makes approved substitutions for the manhole and catch basin sections detailed on the Plans, the Department will pay for accepted quantities based on the prices bid for the quantities of the items replaced by the substitute sections.

SECTION 612 – STONE MASONRY

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DESCRIPTION

612.01 Description

This work consists of constructing stone masonry structures and stone masonry portions of concrete, steel, timber, and composite structures, at the locations shown on the Plans or as directed by the Engineer.

MATERIALS

612.02 Materials

Provide materials as specified in:

Masonry Mortar **912.03**
Masonry Stone **921.07**

612.03 Classification

Stone Masonry will be classified under the following designations:

1. Uniform-Course Stone Masonry shall consist of masonry constructed with roughly squared stones laid in uniform courses, and in which all courses have approximately the same thickness.

2. Nonuniform-Course Stone Masonry shall consist of masonry constructed with roughly squared stones laid in uniform courses, and in which the courses may have different thicknesses.

3. Uncoursed Stone Masonry shall consist of masonry constructed with roughly squared stones of varying thicknesses and not constructed in courses.

4. Rustic Stone Masonry shall consist of masonry constructed with stones broken to various shapes and sizes.

612.04 Reserved

CONSTRUCTION REQUIREMENTS

612.05 Preliminary Work

Before beginning work on stone masonry, perform all necessary Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction as specified in **201**, **202**, **203**, and **205**, respectively.

612.06 Structure Excavation, Foundation Preparation, and Backfill

Perform Structure Excavation, Foundation Preparation, and Backfill as specified in **204**.

The foundation for this type of construction shall present a uniform bearing surface. If a reinforced foundation is necessary, construct it of Class A concrete as specified in **604** or as directed by the Engineer.

612.07 Preparing Stone

Complete all shaping and dressing of stone before the stone is placed. For angles, ends of walls, copings, and similar features, use selected stone that is squared and pitched to line. The exposed faces of stones shall not show tool marks.

Uniform-coursed masonry stone shall be of the thickness shown on the Plans. In any one course of nonuniform-coursed masonry, use stone of the same thickness, with a minimum thickness of 5 inches. In uncoursed masonry, not more than 10% of the stone shall be of the same thickness, with a minimum thickness of 5 inches.

Stone for uniform-coursed masonry, nonuniform-coursed masonry, and uncoursed masonry shall have a width not less than 1-1/2 times the thickness with a minimum of 12 inches, and a length not less than 1-1/2 times the width, unless otherwise shown on the Plans or directed by the Engineer. Headers shall have a width not less than the thickness, with a minimum of 12 inches, and a length sufficient to extend entirely through walls of 2 feet or less in thickness, and at least 1 foot into the core of the wall for walls more than 2 feet thick. Dress the beds and sides of all stone so that adjacent stones will not touch and so that the face joint will not exceed 1-1/2 inches. The face protrusions shall not exceed 2 inches.

Rustic masonry stone shall consist of stone broken to various shapes and sizes and roughly squared back from the face not less than 3 inches. At least 80% of the stone shall have a minimum face dimension (rise) of not less than 6 inches. The other face dimension at right angles to the rise shall not exceed 2 times the rise, or 2 feet, whichever is smaller. The third dimension shall be at least 1-1/2 times the rise with a minimum of 12 inches. Not more than 10% of the stones shall be of the same face dimensions. Headers shall be of such length as to extend entirely through walls of 2 feet or less in thickness, and at least 1 foot into the core of walls more than 2 feet in thickness. Dress the beds and sides of all stones so that the adjacent stones will not touch and so the face joints will not exceed 1-1/2 inches. The face protrusions shall not exceed 2 inches.

612.08 Laying Stone

When shown on the Plans, build, at a site designated by the Engineer, an L-shaped sample section of wall not less than 5 feet high and 8 feet long, showing an example of face wall, end wall, top wall, method of turning corners, and method of forming joints. Do not lay any masonry, other than

the foundation bed, before obtaining the Engineer's approval of the sample walls.

Do not construct stone masonry in freezing weather, or when the stone contains frost.

Construct the bottom of the foundation course of large, selected stones that are laid on bearing beds parallel to the natural bed of the material.

Use larger stones in the bottom courses, and then gradually decrease stone size from the bottom to the top of the wall; however, uniformly distribute stones of various sizes throughout the wall. Prevent small stones or stones of the same size from meeting or bunching.

Use selected large stones, roughly pitched to lines, at all corners and ends of walls.

Uniformly distribute unweathered stones and stones of the same color throughout the exposed faces of the wall to avoid the appearance of patches. Thoroughly clean each stone and moisten with water before setting. Clean and moisten the bed that is to receive the stone before spreading the mortar.

Embed stones in freshly made mortar. The joints shall be full and the stones carefully settled in place before the mortar is set. Stones shall not contact adjacent stones, but shall be suspended in the mortar. Do not set the four corners of adjacent stones to be contiguous unless otherwise indicated or directed.

Build the backing chiefly of large stones laid in full mortar beds, well bonded with each other and interlocked and bonded with the face stones. Completely fill all spaces and interstices with mortar, or with spalls surrounded completely with mortar.

Do not jar or displace stones already set. Do not roll or turn stones on the wall.

If a stone is moved or the joint broken after setting, remove the stone, clean off the mortar from the stone bed and joints, and reset the stones in fresh mortar.

Headers shall hold in the heart of the wall, the same size shown in the face, and shall extend not less than 12 inches into the core or backing, unless otherwise indicated. Uniformly distribute headers throughout the walls of

structures to occupy at least 1/5 of the wall faces. In walls 2 feet or less in thickness, extend headers entirely through the walls.

Except in rustic masonry, spalls will not be permitted in the beds or face joints. The bed joints and beds shall have an average thickness of not more than 1 inch. Horizontal face joints shall be not less than 1/2 inch nor more than 1 inch and shall be approximately uniform in thickness. Vertical face joints shall be not less than 1/2 inch nor more than 1-1/2 inches in thickness.

Lay uniform-course and non-uniform-course masonry to line and grade, and in courses that are roughly leveled up. Break vertical joints in coursed masonry with those in adjoining courses at approximately the middle of the stones.

Lay uncoursed stone masonry to line and with the bed of the stone approximately parallel and level. Do not extend horizontal face joints through more than four stones, and vertical face joints through more than two stones. Break all joints approximately at the middle of the adjacent stones.

Construct rustic stone masonry so that the stone of the various face sizes will be well and uniformly distributed throughout the face of the wall. Prevent small stones or stones of the same size from meeting or bunching. Spalls may be used but shall not be segregated. Construct the joints along the face to be not less than 1/2 inch nor more than 1-1/2 inches in thickness, to have an approximately uniform width, and to not extend in a straight line through more than two stones. Form face joints to run in all directions and at various angles with each other. In general, bed surfaces shall be practically perpendicular to the face of the wall for not less than 3 inches, from which point they may be irregular and fall off not to exceed 3 inches in 12 inches, and shall be free from depressions or projections that will impair the strength of the masonry or hinder the securing of full bearing on the mortar.

Construct weep holes of such shape and size as indicated or directed. Unless otherwise shown on the Plans or directed by the Engineer, space weep holes not over 10 feet center to center, and locate them at the lowest point where free outlet may be obtained. Protect the inlet end of weep holes by placing a wire basket of 1 foot by 1 foot by 1 foot, filled with coarse aggregate, size 7, 8, 57 or 68 immediately over or behind the holes as directed.

Take care at all times to keep the surface free from mortar stains. Immediately after laying and while the mortar is fresh, clean face stones of all mortar stains and keep in a clean condition.

Finish the top edge or course to a true line with a uniform surface on top of the wall.

612.09 Pointing

Properly point face joints before the mortar in the joints sets.

Where raked joints are required, squarely rake all mortar in exposed face joints to a depth of approximately 2 inches before the mortar has set. Use clean water to thoroughly wet joints that are not pointed at the time the stone is laid, and fill with mortar. Ensure that the mortar is well driven into the joints, and then finish with an approved pointing tool.

Where weather joints are required, the bed shall be weather struck. Slightly rake the joints to conform to the bed weather joints. Do not leave the mortar flush with the stone faces. If required by the Engineer, wet the joints and point with mortar.

Rake out joints on top surfaces to a depth of approximately 1 inch at the edges, and crown the mortar to drain.

Keep the walls upon which pointing is being performed moist for a period of at least 72 hours after completion. In hot, dry weather, protect the pointed masonry from the sun during this period.

Do not smear the face surfaces of stone with the mortar forced out of the joints or mortar used in pointing.

After the pointing is completed and the mortar has set, thoroughly clean the stone and leave it in a neat and workmanlike condition.

612.10 Arch Rings

Lay out a full size template of the arch ring near the quarry site, showing face dimensions of each ring stone and thickness of joints. Obtain the Engineer's approval of the template before starting the shaping of any ring stone. Place no ring stone in the structure until all ring stones have been shaped, dressed, and approved.

Construct arch centering in accordance with construction drawings submitted by the Contractor in accordance with **105.02**. Provide suitable wedges for adjusting the elevation of the forms and for taking up any settlement occurring during loading. Lower the centering gradually and symmetrically to avoid overstresses in the arch.

When directed by the Engineer, support centering with approved jacks to take up and correct any slight settlement that may occur after masonry placement begins. In general, strike centering and make the arch self-supporting before placing railing or coping.

Construct, in a manner satisfactory to the Engineer, any additional falsework or bracing needed to hold the stones in position.

Furnish arch ring stones of the size shown on the Plans and dress them to form radial joints not more than 1-inch in width. On the face and soffit, the joints shall be cut hard for a distance of at least 3 inches, from which point, they may fall off not to exceed 1 inch in 1 foot. Completely fill the joints with mortar, and grout if necessary. Point or finish the joints while the mortar is fresh.

Place an anchor composed of 1/2 inch steel bar bent into an elongated letter S in each voussoir joint extending at least 1 foot into the backing and to within 3 inches of the face of the stone.

612.11 Copings, Top Walls, Bridge Seats, and Back Walls

Construct copings, tops of walls, bridge seats, back walls, and similar features to the lines, grades, and cross-sections, and of the material, shown on the Plans or as directed by the Engineer.

For copings, tops of wall, bridge seats, back walls, and similar features to be constructed of concrete, use Class A concrete conforming to the applicable requirements of **604**, unless otherwise shown on the Plans or directed by the Engineer. Construct concrete copings in sections from 5 to 10 feet long and of the width and thickness shown on the Plans.

Construct stone copings of carefully selected stones of the length, width, and thickness shown on the Plans. Construct copings to have a uniform surface and to be pitched to line along the top and bottom edge.

612.12 Finishing and Final Cleanup

Clean exposed surfaces of stone masonry of all mortar, scars, and blemishes so as to provide a surface having a natural color of stones. Use wire brushes and acid that will not mar or damage the stone or mortar when required.

Perform final cleanup as specified in **104.10**.

COMPENSATION

612.13 Method of Measurement

The Department will measure stone masonry, complete in place, by the cubic yard. The volume will include the cubic yards placed within the lines shown on the Plans and typical cross-sections, or as directed by the Engineer. The different classifications of mortar stone masonry will be measured separately. Arch rings will be included in the measurements of the classifications of masonry in connection with which they are constructed, unless otherwise indicated.

The Department will measure concrete used in reinforcing foundations and in copings, tops of walls, bridge seats, and back walls in accordance with **604.30**.

The Department will include copings, tops of walls, bridge seats, and back walls constructed of stone in the measurements of the classification of masonry in connection with which they are constructed.

Unless otherwise shown on the Plans, the Department will not measure structure excavation, and will consider this work incidental to other items of construction. When the Plans provide for direct payment for Structure Excavation, the Department will measure and pay for this work in accordance with **204**.

612.14 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Uniform-Course Stone Masonry	Cubic Yard

612.14

Non-uniform Course Stone Masonry	Cubic Yard
Uncoursed Stone Masonry	Cubic Yard
Rustic Stone Masonry	Cubic Yard

SECTION 613 – BRICK MASONRY

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DESCRIPTION

613.01 Description

This work consists of constructing brick masonry structures, and the brick masonry portions of concrete, steel, timber, and composite structures, at the locations shown on the Plans.

MATERIALS

613.02 Materials

Provide materials as specified in:

Building Brick (Kind and Grade as Specified) **912.01**
Sewer Brick **912.02**
Masonry Mortar **912.03**

613.03 Reserved

CONSTRUCTION REQUIREMENTS

613.04 Preliminary Work

Before beginning work on brick masonry, perform all necessary Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction as specified in **201**, **202**, **203**, and **205**, respectively.

613.05 Structure Excavation, Foundation Preparation, and Backfill

Perform Structure Excavation, Foundation Preparation, and Backfill as specified in **612.06.**

613.06 Mortar

Mortar for brick masonry shall meet **912.03.**

613.07 Laying Brick

Do not construct brick masonry in freezing weather or when the bricks contain frost.

For exposed surfaces, corners, and similar areas, use brick selected from brick that has been approved for color and uniformity.

Immediately before laying brick, thoroughly clean and moisten with water both the bricks and the bed that is to receive the brick.

Lay brick in freshly made mortar, true to the lines and grades shown on the Plans or as directed by the Engineer. Arrange headers and stretchers so as to thoroughly bond the masonry and, unless otherwise indicated or directed, alternate headers and stretchers with consecutive courses breaking joints.

Lay brick in courses so as to be thoroughly bonded with the joints completely filled with mortar.

Lay the courses continuously, and with consecutive courses breaking joints. Neatly strike face joints, using a weather joint. Finish all joints properly as

the laying of brick progresses and to be not less than 1/4 inch nor more than 1/2 inch in thickness.

Do not use spalls or bats except for shaping around irregular openings or when unavoidable to finish out a course, in which case, place a full brick at the corner and the bat in the interior of the course. Use filling materials for the interior of the walls that are of the same quality as used in the face of the unit, unless otherwise shown on the Plans or directed by the Engineer.

Neatly plaster the surface of brick masonry, against which embankment or backfill is to be placed, with mortar to a thickness of not less than 1/2 inch, and finish the mortar to a true and uniform surface. Protect the mortar and keep it wet for 48 hours after completion.

Keep the exposed surface of brick free from mortar stains. Immediately after laying, thoroughly clean face brick of all mortar stains.

Construct weep holes of such shape and size as shown on the Plans or as directed by the Engineer. Space weep holes not over 10 feet center to center, and locate them at the lowest point where free outlet may be obtained, unless otherwise directed by the Engineer. Protect the inlet end of weep holes by placing a wire basket 1 foot by 1 foot by 1 foot filled with coarse aggregate size 7, 8, 57, or 68 immediately over or behind the holes as directed.

In case any brick is moved or the joints break after laying, remove the brick, clean off the mortar from the brick, bed, and joints, and relay the brick in fresh mortar.

Protect brick masonry and keep it wet for a period of 48 hours after laying brick.

Ensure that all brick masonry presents an even, uniform, neat, and workmanlike appearance.

613.08 Copings, Tops of Walls, Bridge Seats, and Back Walls

Construct copings, tops of walls, bridge seats, back walls, and similar features to the lines, grades, cross-sections, and of the material shown on the Plans or as directed by the Engineer.

For copings, tops of walls, bridge seats, back walls, and similar features, to be constructed of concrete, use Class A concrete conforming to the

requirements of **604**, unless otherwise shown on the Plans or directed by the Engineer. Construct concrete copings and similar features in sections from 5 to 10 feet long and of such widths and thicknesses as shown on the Plans or as directed by the Engineer. The sections may be cast-in-place or precast and set in place in full mortar beds. Finish concrete as specified in **604.22**.

For copings, tops of walls, bridge seats, back walls, and similar features to be constructed of stone, use stone masonry of the classifications shown on the Plans or as directed by the Engineer. Construct stone copings of the design and thickness shown on the Plans, using carefully selected large stones of the length, width, and thickness shown on the Plans. The stone shall have a uniform surface and be pitched to line along the top and bottom edge. For all stone, comply with the requirements specified in **612**.

613.09 Finishing and Final Cleanup

Clean brick masonry that is to be exposed in the completed construction of all mortar, scars, and blemishes. The exposed surface shall present a surface having the natural color of the brick.

Perform final cleanup as specified in **104.10**.

COMPENSATION

613.10 Method of Measurement

The Department will measure brick masonry by the cubic yard or by the 1,000 brick, as indicated on the Plans, placed within the lines shown on the Plans and typical cross-sections or as established by the Engineer.

When the Department measures brick masonry by the cubic yard, the volume will include the mortar.

When the Department measures brick masonry by the 1,000 brick, the mortar will not be considered. If fractional parts of brick, of 1/2 brick or greater, are used, the Department will include these parts in the measurements; if less than 1/2 brick, they will not be included.

The Department will measure concrete used in reinforcing foundations and in copings, tops of walls, bridge seats, and back walls in accordance with **604.30**.

The Department will measure copings, tops of walls, bridge seats, and back walls constructed of stone masonry in accordance with **612.13**.

Unless otherwise shown on the Plans, the Department will not measure structure excavation, and will consider the work incidental to other items of construction. When the Plans provide for direct payment for Structure Excavation, the Department will make measurement and payment in accordance with **204**.

613.11 Basis of Payment

The Department will pay for accepted quantities of Brick Masonry at the contract unit price per 1,000 brick, whichever unit is called for on the Plans or in the Contract, complete in place.

SECTION 615 – PRECAST/PRESTRESSED CONCRETE BRIDGE MEMBERS

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DESCRIPTION

615.01 Description

This work consists of manufacturing precast/prestressed structural concrete members and hauling, storing, and placing the precast/prestressed members on a prepared substructure.

Fabricate these items in plants that have been certified by the Precast/Prestressed Concrete Institute (PCI). The fabricator shall be

certified by PCI for the product that it will be manufacturing and supplying to the State or the Contractor.

615.02 Prestressing Methods

Prestress the individual bridge members by pretensioning, post tensioning, or a combination of both methods. Plans for prestressed members will fully detail at least one of these methods. The Contractor may use a prestressing method other than that shown on the Plans if approved by the Engineer.

Fabricate precast/prestressed concrete members in a PCI Category B3 certified plant. Have at each fabrication site a technician skilled in the approved prestressing method. This technician shall give specialized aid and instruction in the use of the prestressing equipment and installation of materials as may be necessary to achieve the required results. The fabricator of precast/prestressed concrete members shall also have at each fabrication site a quality control technician capable of performing all necessary quality control inspection and testing to ensure that the precast/prestressed member is applicable for its intended use. The quality control technician shall have direct lines of communication to engineering, production, and management with responsibility only to management and shall not be subject to control by production (plant superintendent).

MATERIALS

615.03 Materials

Provide materials as specified in:

Portland Cement	**901.01**
Fine Aggregate	**903.01**
Coarse Aggregate	**903.03**
Joint Filler, Preformed Type	**905.01**
Steel Bar Reinforcement	**907.01**
Prestressing Reinforcement Steel and Anchorages	**907.04**
Structural Steel	**908.01**
Elastomeric Bearing Pads	**908.12**
Paints	**910**
Cement Concrete Curing Materials	**913**
Water	**921.01**
Air-Entraining Admixtures	**921.06**
Chemical Additives	**921.06**

Grout, Type 1 ..... **921.09**

EQUIPMENT

615.04 Equipment

Provide equipment as specified in **604.04**. Also provide a Type A field laboratory as specified in **106.06**.

CONSTRUCTION REQUIREMENTS

615.05 General

Construct the substructure for the precast/prestressed structural concrete members as shown on the Plans and as specified in the applicable Sections of these Specifications.

Fabricate the panels in a PCI Category B3 certified plant.

Construct the precast/prestressed structural concrete members in an approved plant under plant control conditions, and place them upon the substructure to the established lines and grades as shown on the Plans.

Ensure that each plant has a quality control plan as specified in **604.03.B**.

615.06 Forms

Unless otherwise allowed, for external forms, provide metal forms that are mortar-tight and sufficiently rigid to prevent distortion due to pressure of the concrete and other stresses incident to the construction operations. The forms shall be substantial and unyielding, and designed, set, and maintained so that the finished concrete will conform to the proper dimensions and contours. Provide forms that are filleted at sharp corners and that have a bevel or draft in the case of projections to allow for easy removal. Wooden bulkheads may be used.

Treat forms with oil immediately before placing the concrete. Do not use any material that will adhere to or discolor the concrete.

Internal forms may be of cellular polystyrene, meeting the requirements specified in Table 615.06-1, or reinforced cardboard.

Table 615.06-1: Cellular Polystyrene

Property	Value
Density (ASTM D1622)	0.90 pounds per cubic foot
Compressive Strength @ 10% Deformation (ASTM D1621)	10 psi minimum
Absorption (ASTM C272)	3% (vol.) maximum

Each individual form shall have a cross-sectional area, equal to the cross-sectional area of the beam void, and a minimum length of 5 feet. When individual forms are constructed by gluing pieces together, use an approved glue. The Engineer will reject forms that show signs of glued joint separations.

615.07 Stressing Requirements - General

Calibrate all jacks, together with their gauges before using in the manufacture of prestressed members. When required by the Department, perform calibrations using proving rings or other acceptable methods performed by an approved testing laboratory at the Contractor's expense. Have a calibration chart for each device readily available on site and also furnish such charts to the Department. Recalibrate jacks and gauges at least once every 6 months. Provide means for measuring the elongation of reinforcement to at least the nearest 1/16 inch.

For all methods of tensioning, determine the force in the tendons by monitoring either the applied force or the elongation, and then independently checking by measuring the other. At the completion of tensioning operations, the two control measurements, force and elongation, shall agree within 5% of the computed theoretical values. If discrepancies exceed 5%, suspend the tensioning operation and use qualified personnel to determine and evaluate the source of error before proceeding. If the source of the discrepancy cannot be determined, recalibrate the devices. Additionally, ensure that the control measurements of force and elongation algebraically agree with each other within 5%. If the measurements do not agree within 5%, the Contractor may add a load cell at the "dead end," and if force measurements agree within 5% between the gauge at the live end and the load cell at the dead end, the Department will waive the requirement for elongation agreement.

When taking elongation and gauge readings, include appropriate allowances for chuck seating, bed shortening under load, abutment rotation, thermal effects, gauge correction based on calibration data, friction, and any other compensation for the setup.

To measure the tensioning force, use one or more of the following methods:

1. Pressure gauges to measure force from the pressure applied to hydraulic jacks.

2. Dynamometers connected in tension into the tensioning system.

3. Load cells connected into the tensioning system so the action of the tensioning operation imparts a compressive force to the sensing element.

4. Digital readouts connected to a pressure transducer to measure force from the pressure applied to the hydraulic jack.

5. Force computed from the actual elongation of the strand based on its physical properties and compensation adjustments.

For pretensioned members, establish independent references adjacent to each anchorage to indicate any yielding or slippage that may occur between the time of initial stressing and final release of the cables.

Stressing of strands for pretensioned members or tendons for post-tensioned members may be from one end, unless otherwise indicated. However, if there is a discrepancy of more than 5% between stresses in the strand or tendon, as computed from the elongation measurement and those indicated by gauge readings, perform jacking from both ends.

615.08 Pretensioning Procedure

Apply to each cable the amount of stress shown on the Plans. Perform pretensioning by either the single strand or multi-strand jacking method.

When prestressing is performed by the multi-strand jacking method, bring the cables to a uniform initial tension of approximately 5,000 pounds before applying the full pretensioning stress. Measure the initial tension of each cable by a dynamometer or other approved means.

After the initial tensioning, stress the cables until the required elongation and jacking pressure are attained and reconciled within the limits specified in **615.07**.

Tension the deflected pretensioned strands by either partially jacking at the end of the bed followed by raising or lowering the strands to their final position, or entirely by jacking, with the strands being held in their final position during the jacking operation.

Tension the deflected strands so that the final tension in all parts of the strand is uniform, and provide means to reduce frictional forces at the bend points to a minimum.

When strands are deflected after partial tensioning, raise or depress the strands simultaneously at all points or in an approved specific sequence.

Obtain the Engineer's approval of strand splicing methods and devices. When using single strand jacking, provide only one splice per strand. When using multi-strand jacking, either splice all strands or no more than 10% of the strands. Spliced strands shall be similar in physical properties, from the same source, and shall have the same "twist" or lay. Locate all splices outside of the prestressed units.

The Engineer may accept wire failures, provided not more than one wire in any strand is broken and the area of broken wires does not exceed 2% of the total area of the strands.

After final stressing, all strands shall be positioned as shown on the Plans, and the stress in the strands shall be uniformly distributed throughout the bed length.

With the cables stressed in accordance with the Plan requirements and the foregoing Specifications, and with all other reinforcing in place, cast the members to the lengths specified. Maintain cable stress between anchorages until the concrete reaches the compressive strength specified in **615.09**.

615.09 Proportioning and Mixing of Concrete

Proportion Class P concrete as specified in Table 615.09-1.

Table 615.09-1: Class P Concrete

Minimum 28-Day Compressive Strength (psi)	Minimum Pounds Cement per Cubic Yard	Maximum Water/Cement Ratio (pound/pound)	Air Content %	Slump (inches)
5,000 (1)	658	0.45	0-8 (2)	2 ± 1 (3)

(1) Or as shown on the Plans or approved shop drawings.

(2) Air entraining is optional with the Contractor, unless otherwise shown on the Plans or shop drawings.

(3) Not to exceed 3 inches before the addition of high range admixtures, and not to exceed 10 inches after the addition of high range admixtures. If water-cement ratio is equal to or less than 0.35 then the maximum slump is 10 inches. If the water-cement ratio is 0.36 – 0.45, the maximum slump is 8 inches.

Comply with all applicable provisions of **604.03** except as modified herein.

Submit a concrete design to the Department for review and approval. In addition to the proportions, identify in the design submittal the source or brand of all materials and the type of cement to be used. The Contractor may use Type I or Type III cement, unless otherwise specified. Do not use calcium chloride. Use a retardant admixture when the ambient temperature is 75 °F or higher. The slump of the concrete shall be 2 inches with a tolerance of ±1 inch at the time of placement. When an approved superplasticizer is to be used, the slump of the concrete shall be the same as above before the superplasticizer is added to the mix. After the addition of the superplasticizer, the slump may be increased to a maximum of 8 inches at the time of placement.

Handle, measure, and batch materials; mix concrete; and comply with the limitations of mixing as specified in **501.09**, **501.10**, and **501.11**, respectively.

Make concrete test specimens, in accordance with AASHTO T 23, to determine the adequacy of the concrete design and the minimum time at which the stress may be applied to the concrete. Cure the test specimens used to determine the time at which stress may be applied in the same manner and under the same conditions as the bridge members. The initial curing of specimens to determine the design strength of the concrete shall be as specified above with additional curing water, as provided in AASHTO

T 23. The compressive strength of the concrete will be determined from the average strength of at least two representative test specimens made and cured as specified above and tested in accordance with AASHTO T 22. The frequency of sampling and testing will be in accordance with the Department's sampling and testing schedule.

615.10 Handling, Placing, and Consolidating Concrete

A. Handling and Placement

Handle and place concrete for prestressed bridge members as follows:

1. Before placing any concrete, clean the forms of construction debris and other extraneous matter. Place and secure the reinforcing bars, of the size and type specified, as shown on the Plans.

2. Place concrete in the forms immediately after mixing. Do not use any concrete that does not reach its final position in the forms within 30 minutes after adding the cement to the mix. Place the concrete so as to prevent segregation of the materials and displacement of the reinforcement.

3. Use metal or metal-lined open troughs and chutes, and keep them clean and free from hardened concrete. Discharge water used in flushing clear of the forms.

4. Keep the temperature of forms, headers, cables, reinforcing bars, or other steel that comes in contact with freshly placed concrete to below 110 °F during casting operation, except keep forms for deck panels below 90 °F.

5. Do not begin to place concrete if the ambient temperature is below 26 °F; and if the ambient temperature falls below 26 °F during the placement of concrete, discontinue the placement as soon as practicable.

6. Do not begin placing concrete during precipitating weather; and if precipitating weather occurs during the pouring operation, only leave the area where the concrete is being placed uncovered. Limit this uncovered area to no more than 10 feet of bed length.

7. Do not deposit any concrete until the Engineer has inspected and approved the placement of the reinforcement, conduits, anchorages, and prestressing steel. Clean all exposed steel of all concrete, other than light deposits of cement paste, immediately after placing and consolidation is completed.

B. Consolidation

During and immediately after the placing operation, consolidate the concrete with vibrators and suitable spading tools. Apply vibration at the point of deposit and in the area of freshly deposited concrete. The vibrators used may be internal or external or a combination of both. Vibrate for a sufficient duration and intensity to compact the concrete thoroughly, but so as not to cause segregation. Place concrete in the precast units in one continuous operation for each unit, except for the minimum delay required for installing voids.

Deposit and consolidate the concrete so that the concrete will be smooth and dense and free from honeycomb and pockets of segregated aggregates. Give roadway surfaces a Class 3 finish as specified in **604.21.C**.

615.11 Removing Forms, Finishing, and Curing

A. Removing Forms

The Contractor may remove side forms as soon after 6 hours as their removal will not cause distortion of the hardened concrete. Do not remove the members from the bottom forms until they have been stressed sufficiently to sustain all forces and bending moments that may be applied during handling.

B. Finishing

Finish all formed surfaces of the bridge members as specified in **604.22**. The Contractor may use other methods when approved by the Engineer. Finish roadway surfaces of the members as specified in **604.21.C**. Transversely score the top surface of members that will not become a part of the roadway surface with a stiff wire brush, or by other approved methods. After removing hold down devices from the bottom of the beams, coat the resulting holes with an approved bonding compound and plug with mortar.

C. Curing

Cure the bridge members by the water method or by steam curing as specified below. The Contractor may use other methods, provided the details of the proposed methods are submitted to the Department and approved.

1. Water Curing. As soon as the concrete has hardened to a degree that the finish will not be harmed, perform water curing as follows:

a. Cover the member with a pre-dampened material suitable for use with the water cure.

b. Keep continuously and thoroughly wet until the member has attained the strength required for stress transfer with a minimum curing time of 24 hours.

Do not cure using the water method when the ambient temperature is expected to drop below 45 °F.

2. Steam Curing. Perform steam curing as follows:

a. After placing and vibrating the concrete, wait until the member attains initial set, 2 to 4 hours, or 4 to 6 hours if a set retarder has been used, before applying steam. If the ambient air temperature is below 50 °F, apply enough steam during the delay period to hold the air surrounding the member at a minimum temperature of 50 °F and a maximum of 10 °F greater than the temperature of the concrete at placement.

b. To prevent moisture loss on exposed surfaces during the delay period, cover members as soon as possible after casting or keep the exposed surfaces wet by fog spray or wet blankets.

c. Perform steam curing beneath suitable enclosures that will allow free circulation of steam about the sides, ends, and tops of members, and that will contain the live steam with a minimum moisture loss. The Contractor may use tarpaulins or similar flexible covers, provided they are kept in good repair and secured in a manner that will prevent the loss of significant steam and moisture.

d. Steam at the jets shall be low pressure and in a saturated condition. Steam jets shall not impinge directly on the concrete, test cylinders, or forms. During application of the steam, the temperature rise within the enclosure shall not exceed 50 °F per hour. The curing temperature throughout the enclosure shall be not less than 90 °F nor more than 160 °F, and the relative humidity shall be not less than 95%. The difference in the temperature adjacent to the concrete at different locations within the enclosure shall not exceed 20 °F at any time. Continue steam curing until the concrete has reached the required transfer strength. In discontinuing the steam, do not reduce the temperature within the enclosure more than 50 °F per hour until the temperature inside is within 10 °F of the temperature outside. The minimum time from the end of placement and finishing operations to the removal of required covers shall not be less than 12 hours.

e. When curing has been done at elevated temperatures, begin to transfer the prestressing load after releasing the forms and discontinuing the steam and while the concrete is still hot in order to prevent cooling shrinking and cracking. If so directed by the Engineer, cover members or otherwise protect them so as to cool the concrete slowly after release in order to prevent thermal shock and the evaporation of moisture in the members.

f. Provide temperature recording devices that will provide an accurate continuous permanent record of the curing temperature. Provide a minimum of one recording device per 200 feet of continuous bed length with a minimum of two devices per bed.

g. Leave side forms in place a minimum of 6 hours after the concrete is cast or until the concrete has set sufficiently to withstand damage when the forms are removed. When the side forms are removed during the curing cycle, only remove the minimum area of the curing enclosure that is necessary to remove each individual form section area in the enclosure. Immediately close the open area in the enclosure as each form section is removed.

h. When the temperature is not expected to rise above 32 °F, protect the beams from freezing temperatures until the design strength is reached.

615.12 Post-Tensioning Procedure

When post-tensioning, set the anchor plates normal in all directions to the axis of the steel. In all stressing operations, keep the stressing forces symmetrical about the vertical axis of the member. Do not begin tensioning until the concrete has reached a compressive strength of at least 3,500 pounds per square inch, unless otherwise shown on the Plans.

The amount of tensioning to be retained in each post-tensioned unit after anchorage shall be as shown on the Plans. Apply a slight overstress, as determined in the field, to overcome friction between steel and enclosure and to allow for relaxation of the anchorage.

Tension the units until the required elongations and jacking pressures are attained and reconciled within the limits specified in **615.07**, with such overstress as approved by the Engineer for anchorage relaxation. Then allow the male anchorage element to be driven home by the jack action.

Conduct the tensioning process so that the tension being applied and the elongation of the prestressing elements may be measured at all times. Determine the friction loss in the element, i.e., the difference between the tension at the jack and the minimum tension, in accordance with the current edition of AASHTO Standard Specification for Highway Bridges.

615.13 Combined Prestressing and Post-tensioning

If the members are manufactured with part of the reinforcement pre-tensioned and part post-tensioned, comply with the applicable portions of the requirements specified above for each part.

615.14 Transfer of Stress

Do not transfer the stress to the bridge members until the test specimens indicate that the concrete has reached a compressive strength of at least 4,000 pounds per square inch, unless otherwise shown on the Plans.

Before transferring any stress to the bridge members, obtain the Engineer's approval of the pattern and schedule for releasing the strands. Strip or

loosen forms that tend to restrict the horizontal or vertical movement of the member prior to stress transfer.

Transfer stress by either the multiple strand release method or the single strand release method.

When the multiple strand method of release is used, gradually and simultaneously release either a symmetrical group of strands or all of the strands. Remove the load on the strands from the anchorage and place on the jacking system. Gradually release the jack or jacks until the strands are relaxed.

When the single strand release method is used, heat strands with a low oxygen flame played along the strand for a minimum of 3 inches until the metal gradually loses its strength and allows the strand to slowly pull itself apart. Apply heat at such a rate that failure of the first wire in each strand will not occur until at least 5 seconds after heat is first applied. Release the strands in the sequence of the approved pattern and schedule of release.

615.15 Handling and Installation

Prepare an erection plan in accordance with **602.42** and with the requirements of this Subsection.

The Contractor may handle all members immediately after completion of stressing. If the stressing is not done in a continuous operation, do not handle members before they are sufficiently stressed, as determined by the Engineer, to sustain all forces and bending moments due to handling. When handling members, maintain them in an upright position at all times and pick them up from the points designated on the Plans.

The Contractor may incorporate the members into the bridge structure at any time after completion of stressing and grouting, provided representative test specimens indicate that the concrete in the members has attained the design strength specified in **615.09**, unless a minimum beam age is shown on the Plans.

Do not ship any beams from the fabrication plant for incorporation into a structure until the Department has formally accepted the beams in accordance with Departmental procedures.

Erect all prestressed beam members and establish the grade of the roadway on the bridge before starting forming for the bridge deck, unless otherwise shown on the Plans or approved by the Engineer.

If the Contractor wishes to start forming for the bridge deck before all beams have been erected, and the Plans do not preclude this practice, first obtain written approval from the Structures Division before constructing any forms.

615.16 Grouting

Equip conduit, used for installing the bars or cables through post-tensioned members, with approved grouting vents. After completion of stressing, grout the space between sides of bar or cable and sides of conduit as specified in **616.09**.

Clean recesses in girders at the ends of diaphragm bars, holes left by form ties, or all other surface irregularities, and patch with an approved epoxy grout.

615.17 Tolerances

Unless otherwise specified, standard sections shall meet the manufacturing tolerances specified in Table 615.17-1. Any variation beyond these tolerances will be subject to the Engineer's approval.

Table 615.17-1: Manufacturing Tolerances in Standard Sections

Description	Tolerance	
	I-Sections	**Box Sections**
Nominal Depth	± 1/2 inch	± 1/2 inch
Nominal Width	± 1/2 inch	± 1/2 inch
Nominal Length	Computed Elastic Shortening ±1/2 inch	Computed Elastic Shortening ±1/2 inch
Variation in Straightness, inches	1/4 inch x (Total Length in feet)/10	1/4 inch x (Total Length in feet)/10
Variation in Camber, inches	Beams in any 1 span not more than: 1/8 inch x (Total Length in feet)/10	Beams in any 1 span not more than: 1/8 inch x (Total Length in feet)/10
Location of Voids	---------	Length ± 1-1/2 in Wall Thickness ± 1/2 in
Bearing	Full Bearing - Full Width of Beam	Full Bearing on at Least 2/3 of Width of Beam
Tendon Placement	± 1/2 inch	± 1/2 inch
Reinforcing Steel Placement	± 1/2 inch	± 1/2 inch
Reinforcing Steel Concrete Cover	± 1/2 inch	± 1/2 inch
Reinforcing Steel Splice Lengths	Minus 1-1/2 inches	Minus 1-1/2 inches

COMPENSATION

615.18 Method of Measurement

The Department will measure structural members by the linear foot of precast/prestressed concrete structural members of the several types and sizes installed, complete in place. The Department will determine the linear measurement from the nominal lengths shown on the Plans.

615.19 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Prestressed Concrete I-Beam (Type)	Linear Feet
Prestressed Concrete Bulb Tee Beam (Size)	Linear Feet
Precast Concrete Beam (Description)	Linear Feet
Prestressed Concrete Box Beam (Size)	Linear Feet
Prestressed Concrete Beam (Size, Description)	Linear Feet
Concrete Channel (Size)	Linear Feet

If the Engineer allows concrete that does not meet the specified strength to remain in the permanent construction, the Department will adjust the bid price in accordance with 604.31.

SECTION 616 – POST-TENSIONED PRESTRESSED CONCRETE

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DESCRIPTION

616.01 Description

This work consists of prestressing cast-in-place concrete by furnishing, placing, and tensioning prestressing steel in accordance with the Plans and these Specifications, and furnishing and installing all appurtenant items necessary for the particular prestressing system to be used, including ducts, anchorage assemblies, prestressing steel, and grout.

616.02 Prestressing Methods

Perform prestressing using post-tensioning methods.

Submit to the Engineer for review and approval complete details of the proposed method, materials, and equipment to use in the prestressing operations, including any additions or rearrangement of reinforcing steel from that shown on the Plans. Such details shall outline the method and

sequence of stressing and shall include complete specifications and details of the prestressing steel and anchoring devices, working stresses, bursting stresses, anchoring stresses, type of ducts, and all other data pertaining to the prestressing operation, including the proposed arrangement of the prestressing steel in the members, pressure grouting materials, and equipment. Do not cast any member to be prestressed until the Engineer approves the shop detail drawings.

MATERIALS

616.03 Materials

Provide materials as specified in:

Portland Cement (Type I or III)	**901.01**
Prestressing Reinforcement Steel and Anchorages	**907.04**
Water	**921.01**

All components of the post-tensioning system shall be certified to meet the Post-Tensioning Institute (PTI) *Acceptance Standards for Post-Tensioning Systems*.

616.04 Reserved

CONSTRUCTION REQUIREMENTS

616.05 Protection and Installation of Prestressing Steel

Locate the prestressing steel in the girder stems with an equal force in each stem. At the Contractor's option, the prestressing force may vary 5% from the theoretical equal force per girder provided the required total force is obtained and the force is distributed symmetrically about the centerline of the typical section. Tension stressing units a few at a time in each girder to minimize stress differentials. Obtain the Engineer's approval of the stressing sequence.

Protect prestressing steel against physical damage and rust or other results of corrosion at all times. Do not use prestressing steel that is physically damaged. Light surface rust is not a cause for rejection.

Package prestressing steel in containers or other shipping forms to protect the steel against physical damage and corrosion during shipping and storage. Place an approved corrosion inhibitor in the package or form. Alternatively, the Contractor may use a corrosion inhibitor carrier type packaging material or, when allowed by the Engineer, may apply corrosion inhibitor directly to the steel. Ensure that the corrosion inhibitor will have no deleterious effect on the steel or concrete or bond strength of steel to concrete. Immediately replace or restore to original condition all damaged packaging or forms.

If choosing to use a corrosion inhibitor carrier type packaging material, ensure that the material conforms to Federal Specification MIL-P-3420.

Mark the shipping package or form with a statement that the package contains high-strength prestressing steel that should be handled with care. Also identify the type, kind, and amount of corrosion inhibitor used, including the date when placed, safety regulations, and instructions for use.

Submit the following for the corrosion inhibitor:

1. A sample, a list of chemicals and their proportions, and instructions for use.

2. Evidence that the prestressing steel will be protected from rust and other results of corrosion.

3. A certificate of compliance.

When acceptable prestressing steel for post-tensioning is installed in ducts after completion of concrete curing, complete the stressing and grouting within 10 calendar days after installing the prestressing steel. Rust that may form during these 10 days will not be cause for rejection of the steel. If prestressing steel is installed, tensioned, and grouted within 10 calendar days after concrete curing, it is not necessary to use a corrosion inhibitor in the duct following installation of the prestressing steel. If prestressing steel is installed as specified above but is not grouted within 10 calendar days, use an approved corrosion inhibitor in the duct. Ensure that the corrosion inhibitor is maintained at an effective level until grouting is complete.

Do not make any welds or grounds for welding equipment on the forms or on the steel in the member after the prestressing steel has been installed.

Place tendons in rigid ducts after completing concrete placement. Provide ducts as shown on the Plans and as specified in **616.07**.

616.06 Anchorages and Distribution

Anchor post-tensioned prestressing steel at the ends using approved permanent type anchoring devices capable of producing a stress of not less than 95% of the guaranteed minimum tensile strength of the prestressing steel.

Distribute the load from the anchoring device to the concrete using approved devices.

Place bearing plates normal to the tendon path and tight against forms. Brace and anchor forms to support the weight of the bearing plates.

Use approved plates and assemblies that conform to the following requirements:

1. The final unit compressive stress on the concrete directly underneath the plate or assembly shall not exceed 3,000 pounds per square inch.

2. Bending stresses in the plates or assemblies induced by the pull of the prestressing shall not exceed the yield point of the material or cause visible distortion in the anchorage plate when 100% of the ultimate tensile strength is applied as determined by the Engineer.

If the anchoring device is sufficiently large and is used in conjunction with a steel grillage embedded in the concrete that effectively distributes the compressive stresses to the concrete, the Contractor may omit steel distribution plates or assemblies.

Where the end of a post-tensioned assembly will not be covered by concrete, recess the anchoring devices so that the ends of the prestressing steel and all parts of the anchoring devices will be at least 2 inches inside of the end surface of the members, unless a greater embedment is shown on the Plans. Following post-tensioning, fill the recesses with grout, and finish flush. Use a suitable corrosion inhibitor to protect exposed anchorage hardware before final embedment in concrete.

Include complete details of jacking chairs in fabrication drawings to allow verification of proper reinforcement clearances.

616.07 Ducts

Use mortar-tight ducts that are sufficiently rigid to maintain their shape and alignment during concrete placement and grout installation. Ducts shall remain water-tight. Use ducts having the following minimum wall thicknesses:

1. High Density Polyethylene (HPDE): 2.0 millimeter

2. High Density Polypropylene (HDPP): 2.0 millimeter

For tendons composed of single prestressing bars, provide ducts with a minimum internal duct diameter of at least 1/4 inch larger than the outside diameter of the prestressing bar. For multiple wire, bar, or strand tendons, provide a duct nominal internal cross-sectional area of at least 2.25 times the net area of the prestressing steel.

Make positive joints between duct sections. Do not make angles at the joints. Use waterproof tape at the joints. Bend ducts without crimping or flattening. Use ferrous metal or polyethylene couplings to connect ducts to anchoring devices.

Protect ducts against crushing, excessive bending, dirt contamination, and corrosive elements, during transport, storage, and handling of ducts.

In case of damage to a duct, seal it with tape, or splice a duct coupler over the damaged section to form a seal that prevents cement paste from entering the duct during the placement of concrete and that prevents leakage during grouting operations.

Provide all ducts and anchorage assemblies with inlets for the injection of grout into the duct after prestressing according to the PTI *Guide Specification for Grouting of Post-Tensioned Structures*.

Provide all ducts with outlets to allow the escape of air, water, grout, and bleed water according to the PTI *Guide Specification for Grouting of Post-Tensioned Structures*.

Provide inlets and outlets with an inner diameter of at least 3/4 inch for strand tendons and of at least 3/8 inch for single bar tendons. Extend the length of outlets a sufficient distance out of the concrete member to allow for the proper closing of the outlets.

Place inlets and outlets, at a minimum, in the following locations:

1. The anchorage area of the tendon;

2. All high points of the duct, when the vertical distance between the highest and lowest point is more than 2 feet; and

3. At major changes in the cross-section of the duct, such as couplers and anchorages.

In addition, place:

1. An inlet at or near the lowest point of the tendon;

2. A free draining outlet at all low points of the duct; and

3. An outlet at a distance less than 3 feet downstream from high point outlets.

Show all inlet and outlet locations on drawings.

Provide positive mechanical shut-off valves for all inlets and outlets. Provide inlets and outlets with valves, caps, or other devices capable of withstanding the grouting pressure.

Securely fasten ducts in place to prevent movement. Maintain distances from the forms by stays, blocks, ties, hangers, or other approved supports. Use precast blocks. Space all duct supports in accordance with the PTI *Guide Specification for Grouting of Post-Tensioned Structures*. Cover the ends of ducts to prevent the entry of water or debris.

Connect inlets and outlets to the duct with metallic or plastic structural fasteners. Do not use components that react with the concrete, cause corrosion of the prestressing steel, or contain water-soluble chlorides.

616.08 Prestressing

Tension prestressing steel using hydraulic jacks so that the force in the prestressing steel is not less than the value shown on the Plans. Do not perform stressing on a single strand pull. Use a jack that is capable of making a multiple pull on all strands in a tendon.

Unless otherwise specified or shown on the Plans, the stress in the prestressing steel after all losses shall not exceed 80% of the yield point stress of the prestressing steel. The maximum temporary tensile stress (jacking stress) in the prestressing steel shall not exceed 90% of the yield point stress of the prestressing steel. Anchor the prestressing steel at stresses (initial stress) that will result in the ultimate retention of working forces of not less than those shown on the Plans, but in no case shall the initial stress at the anchor exceed 70% of the specified minimum ultimate tensile strength of the prestressing steel.

Working force and working stress will be considered as the force and stress remaining in the prestressing steel after all losses, including creep and shrinkage of concrete, elastic compression of concrete, relaxation of steel, losses in post-tensioned prestressing steel due to sequence of stressing, friction and take up of anchorages, and all other losses peculiar to the method or system of prestressing have taken place or have been provided for.

The loss in stress due to all causes in post-tensioned prestressing steel shall be in accordance with the AASHTO Bridge Specifications designated on the Plans.

Equip each jack used to stress tendons with either a pressure gauge or a load cell for determining the jacking stress. Use a pressure gauge that has an accurately reading dial at least 8 inches in diameter. Calibrate each jack and its gauge as a unit with the cylinder extension in the approximate position that it will be at final jacking force. Keep a certified calibration chart with each gauge. Ensure that each gauge is capable of reading loads directly in pounds or is accompanied by a chart from which the dial reading can be converted to pounds.

If a load cell is used, calibrate it and provide it with an indicator that will allow determination of the prestressing force in the tendon. Do not use the lower 10% of the manufacturer's rated capacity of the load cell to determine the jacking stress.

Provide means for measuring the elongation of reinforcement to at least the nearest 1/16 inch.

The Engineer may check the certified calibration charts for the hydraulic jacks, pressure gauges, or load cells used for tensioning prestressing steel before and during tensioning operations.

Prior to placing forms for closing slabs of box girder cells, demonstrate to the satisfaction of the Engineer that all ducts are unobstructed.

Except as herein provided, do not prestress cast-in-place concrete until at least 10 days after the last concrete has been placed in the member to be prestressed and until the compressive strength of the last placed concrete has reached the strength specified for the concrete at the time of stressing.

Conduct the tensioning process so that the tension being applied and the elongation of the prestressing steel may be measured at all times. Keep a record of gauge pressures or load cell readings and elongations for each tendon stressed.

Use elongation measurements as the primary control of the stressing operation; however, ensure that the hydraulic pressure gauge readings or the load cell readings at the time of the measured net elongation are within 5% of the calculated gauge or load cell reading for that particular elongation. If the gauge or load cell pressure readings vary by more than 5% from their calculated reading, stop all work and correct the defect before proceeding. A variance of more than 5% may be cause for jacking at both ends.

Tension prestressing tendons in continuous post-tensioned members by jacking at each end of the tendon unless otherwise shown on the Plans. Such jacking of both ends need not be done simultaneously. When approved by the Engineer, the Contractor may tension bent cap tendons by jacking from one end only.

The Contractor may tension prestressing tendons in single span post-tensioned members by jacking from one end only. When tensioning is done from one end only, tension half of the prestressing steel in each member from one end of the span and the other half from the opposite end, unless otherwise allowed by the Engineer.

616.09 Bonding and Grouting

Provide Class A, B, C, or D grout as specified in the PTI *Guide Specifications for Grouting of Post-Tensioned Structures*. Bond all post-tensioned prestressing steel to the concrete by filling the void space between the duct and tendon with grout according to the PTI Guide.

Provide prestressing steel that is free of dirt, loose rust, grease, or other deleterious substances.

Perform all grouting operations using staff with grouting experience on projects of a similar type and magnitude. Perform grouting operations under the immediate supervision of an individual skilled in various aspects of grouting and who is certified by the American Segmental Bridge Institute (ASBI) Grouting Certification or equivalent certification program, approved by the Engineer. Furnish the name of the grouting operations supervisor and proof of their ASBI certification and grouting experience to the Engineer before beginning grouting operations.

Make available on-site, before beginning grouting operations, all of the required testing equipment for checking grout workability (flow-cone), temperatures, and other specified tests.

Provide written certification that all ingredients used in the grout meet the ASTM requirements contained in the *PTI Guide Specification for Grouting of Post-Tensioned Structures*. This includes, but is not limited to, the following:

- Cement mill test reports;
- Mineral additives test reports;
- Chemical admixtures reports; and
- Test reports for any other ingredients used in the grout.

For prepackaged grouts, provide the manufacturer's current certified mill test reports for the product.

Use grouting equipment capable of continuous operation with little variation of pressure, which includes a system for recirculating the grout while actual grouting is not in progress. Use grouting equipment capable of maintaining a pressure on completely grouted ducts and fitted with a valve that can be locked off without loss of pressure in the duct.

Do not use compressed air to aid in the pumping of grout.

Provide grout pumps of a positive displacement type, capable of providing a continuous flow of grout, and capable of maintaining an outlet pressure of at least 150 pounds per square inch and with a pressure gauge having a full-scale reading of not more than 300 pounds per square inch.

Determine the flowability of the grout according to ASTM C939. The efflux time of a grout sample immediately after mixing shall be between 11 and 30 seconds. Do not begin grouting until this test is passed. When hot

weather conditions may cause quick setting of the grout, cool the grout by approved methods, as necessary, to prevent blockages during pumping operations. When freezing weather conditions are possible during and following placement of grout, protect the grout from damage by freezing according to the PTI *Guide Specification for Grouting of Post-Tensioned Structures*.

Provide a supply of potable water and standby flushing equipment capable of developing a pumping pressure of 250 pounds per square inch and of sufficient capacity to flush out any partially grouted ducts.

Clean ducts of all material that would impair bonding of the grout or interfere with grouting procedures. Blow out each duct with compressed, oil-free air. Check all inlets and outlets for their capacity to accept injection of grout by blowing compressed, oil-free air through the system, and proving each inlet and outlet in turn.

Pass all grout through a screen with 1/8-inch maximum clear openings before entering the grout pump. Open all grout vents before the start of grouting. Completely fill the duct by injecting grout from the lowest end of the tendon in an uphill direction. Pump grout continuously through the duct and waste at the outlet until no visible slugs of water or air are ejected, and the efflux time of the ejected grout is between 11 and 30 seconds. Maintain a continuous, one-way flow of grout within a grouting stage.

Close all outlets in a similar manner one after the other in the direction of the flow. For outlets placed a short distance downstream from a high point, close that outlet before its associated high point outlet. Increase the grouting pressure at the injection end to at least 100 pounds per square inch and hold for at least 10 seconds. Do not remove or open valves and caps until the grout has set.

Abrasive blast-clean the concrete surface of recessed anchorage assemblies. Fill anchor recesses with concrete conforming to the requirements for the structure, and finish flush.

Remove ends of vents 1 inch below the roadway surface after grouting has been completed. Permanently seal all recess areas.

Do not release the falsework under the bottom slab supporting the superstructure until at least 48 hours after grouting of the post-tension prestressing steel or until the grout strength is obtained.

616.10 Form Work

Do not remove falsework until all prestressing is complete and the structure has been post-tensioned to the Engineer's satisfaction.

616.11 Sampling and Testing

Provide the following to the Engineer well in advance of anticipated use:

1. Furnish one 6-foot long sample of each size strand for each reel.

2. Test one completely fabricated tendon at a laboratory approved by the Department and furnish a notarized letter to the Division of Materials and Tests from the laboratory stating that no deformation has occurred in the anchor head and no slippage of strand has occurred at the wedges.

When prestressing systems have been previously tested and approved for similar projects by an agency acceptable to the Department, testing will not be required, provided the Contractor furnishes the Engineer with a notarized letter stating that the system is the same as a previously tested system.

COMPENSATION

616.12 Method of Measurement

The Department will measure prestressing of cast-in-place concrete by the lump sum as shown on the Plans.

The Department will not measure, and will consider incidental to the work, the furnishing and placing of additional deformed bar reinforcing steel required by the particular system used; ducts, anchoring devices, distribution plates or assemblies, and incidental parts; and the grouting of recesses and pressure grouting of ducts.

616.13 Basis of Payment

The Department will pay for prestressing cast-in-place concrete by the lump sum.

Such payment is full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all work involved in furnishing,

placing, and tensioning the prestressing steel in cast-in-place concrete structures, complete in place, as shown on the Plans, as specified in these Specifications, and as directed by the Engineer.

If the Engineer allows the concrete that does not meet the specified strength to remain in the permanent construction, the Department will adjust the bid price in accordance with **604.31**.

SECTION 617 – BRIDGE DECK SEALANT

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DESCRIPTION

617.01 Description

This work consists of furnishing and placing a waterproofing system over a properly prepared concrete bridge deck for the purpose of protecting structural concrete from the deterioration caused by absorption of deicing salts and water.

MATERIAL

617.02 Materials

Provide materials as specified in:

Bridge Deck Sealant, System A or B **906.04**

617.03 Reserved

CONSTRUCTION REQUIREMENTS

617.04 General

To minimize the amount of construction traffic on the bridge deck seal after placement, do not install the seal until all major phases of roadway

construction have been completed. Complete the roadway base and pavement up to the surface course before beginning installation of the bridge deck seal. The construction of the bridge deck sealant and overlay may be performed concurrently with or after the roadway surface course.

Obtain the Engineer's approval of all methods used in performing the work before the work is started. If, at any time, the Engineer finds the methods to be unsatisfactory, make changes and improvements as required.

Protect concrete surfaces, structural steel, railing, passing vehicles, and similar surfaces from being defaced by sealant. Should defacement occur, clean surfaces on the structure to the Engineer's satisfaction. Assume sole responsibility and liability for damage to passing vehicles.

Limit traffic on the area being treated to the necessary workers and equipment to perform the work required. Maintain all other traffic on portions of the structure that are not being given the membrane protective coating. At all times, keep traffic off the membrane, and protect the membrane from damage. Repair damage that may occur by patching in a manner satisfactory to the Engineer.

617.05 Weather Limitations

Do not apply sealant during wet weather conditions, when the relative humidity exceeds 85%, or when the surface upon which the sealant is being placed or the ambient air temperature is below 50 °F. Ensure that the surface upon which the sealant is being placed is dry at the time of application.

617.06 Membrane Application

Before applying the membrane, ensure the bridge deck is clean from all debris that would interfere with the membrane adhering to the deck. Check the manufacturer's recommendations about tack/primer coat between the deck and membrane.

Apply the waterproofing membrane to form a butt joint with the face of the curbs. Place the membrane so as to achieve a shingling effect that will allow any accumulated water to drain toward the low curb or the drain pipes. Overlap each strip longitudinally and transversely a minimum of 4 inches or as recommended by the manufacturer. In all cases, begin the waterproofing at the low point of the surface to be waterproofed so that water will run over and not against the laps.

Operate the paving equipment in the direction of the transverse lap of the membrane.

Apply the prefabricated membrane to the bridge deck by either hand methods or mechanical applicators.

Use a wide tipped torch to cause tackiness or an adhesive if necessary to ensure a good seal of the joints. Use hand rollers or other satisfactory pressure apparatus on the applied membrane to ensure firm and uniform contact with the bituminous overlay. Take special care at the curb face to ensure that the membrane uniformly adheres to the concrete. Apply a mastic, of the type specified by the manufacturer, to the butt joints at face of the curb as shown on the Plans. At all open joints, expansion joints, and at other joints as directed by the Engineer, apply the membrane to form a butt joint with the face of the joint, and apply mastic as shown on the Plans.

Ensure that the entire membrane is free of placement defects such as wrinkles, air bubbles, and fishmouths. Patch all torn or cut areas, or narrow overlaps, using a satisfactory adhesive and by placing sections of the membrane over the defective area so that the patch extends at least 6 inches beyond the defect. Roll or firmly press the patch onto the surface. Remove air bubbles, caused by the formation of vapor pressure or out-gassing under the membrane after placement, by puncturing the membrane and repairing the defective area in the manner specified above for cut and torn areas.

After completing the membrane waterproofing, cut the membrane with two right angle cuts at all deck drain pipes. Make the cuts to the inside diameter of the drain pipes, and then turn down the corners of the membrane waterproofing into the drains and lay them in a coating of mastic.

Begin applying the bituminous overlay immediately after completing the membrane placement.

Apply a bond coat of an acceptable adhesive to the surface of prefabricated membranes, if required, according to the membrane manufacturer's recommendations before placing the overlay.

Overlay the waterproofing system with asphaltic concrete of the type and in the quantity shown on the Plans.

All requirements of **Part 4** of these Specifications shall apply to this construction with the following revisions and additions:

1. The paving operation shall be in the same direction as the end laps of the membrane.

2. The requirements for automatic grade and slope controls on the paver will be waived.

3. The density requirements will be waived; however, all other applicable compaction requirements in **407.15** will apply. Give the first asphalt concrete lift a breakdown roll as soon as possible after the paving machine has passed.

Deposit, spread, and roll the overlay so as not to damage the membrane.

COMPENSATION

617.07 Method of Measurement

The Department will measure and pay for bridge deck sealant, complete in place, by the number of square yards of bridge deck and approach slabs covered.

The Department will measure and pay for tack coat, when used, and bituminous layers as provided for in **403**.

617.08 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Bridge Deck Sealant	Square Yard

Such payment is full compensation for the preparation of surfaces, and furnishing and applying the waterproofing system complete in place.

SECTION 619 – POLYMER MODIFIED CONCRETE BRIDGE DECK OVERLAY FOR NEW AND EXISTING BRIDGES

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DESCRIPTION

619.01 Description

This work consists of constructing a polymer modified concrete (PMC) bridge deck overlay for the purpose of protecting structural concrete from the deterioration caused by absorption of deicing salts and water.

MATERIALS

619.02 Materials

Provide materials as specified in:

Portland Cement (Type I or Type III)..... **901.01**
Fine Aggregate (Natural Sand)..... **903.01**
Coarse Aggregate (Size 7)..... **903.03**
Water..... **921.01**

Use a polymer that appears on the Department's QPL.

619.03 Proportioning

Proportion the polymer modified concrete mixture to contain no less than 658 pounds of cement per cubic yard and to meet the requirements specified in Table 619.03-1.

Table 619.03-1: Polymer Modified Concrete Mixture - Proportioning

Component	Value
Type I or III Portland Cement	94 pounds
Polymer Admixture	3.5 gallons
Natural Sand	215 to 255 pounds
Coarse Aggregate	208 to 168 pounds
Water (including free moisture on the sand and coarse aggregate)	8 to 22 pounds

The polymer modified concrete mixture shall meet the properties specified in Table 619.03-2.

Table 619.03-2: Polymer Modified Concrete - Required Properties

Property	Value
Slump (measured 4 to 5 minutes after discharge from a continuous mixer)	4 to 6 inches
Air Content	0 to 8%
Water-Cement Ratio	Not more than 0.40 considering all the non-solids as part of the water

The polymer admixture shall contain a minimum of 46% solids. Submit to the Department in writing a concrete design identifying the name and location of aggregate suppliers, and the type and brand of the cement and

polymer proposed for use. Do not place any concrete before obtaining the Department's approval of the design. Do not change materials without the Engineer's written approval.

EQUIPMENT

619.04 Equipment

Obtain the Engineer's approval as to the design, capacity, and mechanical condition of all equipment and tools necessary for handling materials and performing all parts of the work. Have the equipment onsite sufficiently ahead of the start of construction operations to allow for the Engineer's examination and approval.

A. Mixer

Use a continuous type mixer, calibrated to accurately proportion the specified mix, to mix and discharge the PMC overlay. Equip the mixer so that the proportions of the cement, natural sand, and coarse aggregate can be fixed by calibration of the mixer and cannot be changed without destroying a seal or other indicating device affixed to the mixer by the Engineer.

Equip the mixer with a flow meter for calibrating the water supply portion of the mixer. In addition, also equip the mixer with a cumulative-type water meter that can be read to the nearest 0.1 gallon. The water meters shall be readily accessible, accurate to within 1%, and easy to read. The Engineer will check both water meters each time the mixer is calibrated.

Use approved methods to add the admixture so as to keep it separated as far as is practicable.

Calibrate the continuous type mixer to the Engineer's satisfaction before starting the work. Conduct yield checks for each 50 cubic yards of mix. Recalibration will be necessary when indicated by the yield checks, and at any other times the Engineer deems necessary to ensure proper proportioning of the ingredients. Do not use continuous type mixers that entrap unacceptable volumes of air in the mixture. Do not use batch type and drum-type transit truck mixers or rotating drum batch type mixers to mix PMC overlay concrete. Keep the mixer clean and free of partially dried or hardened materials at all times. Ensure that

the mixer consistently produces a uniform, thoroughly blended mixture within the specified air content and slump limits. Immediately repair or replace malfunctioning mixers.

B. Placing and Finishing Equipment

Provide hand tools for placing and brushing-in freshly mixed polymer modified concrete and for distributing it to approximately the correct level for striking-off with the screed.

Use an approved finishing machine complying with the following requirements for finishing large areas of work.

1. Use a self-propelled finishing machine capable of forward and reverse movement under positive control. Provision shall be made for raising all screeds to clear the screeded surface for traveling in reverse.

2. The Contractor may use a self-propelled finishing machine equipped with one or more rotating rollers, augers, and 1,500 to 2,500-vpm vibratory pans.

3. The machine shall be of the vibrating-screed type designed to consolidate the modified composition by vibration. Vibration frequency shall be variable with positive control between 3,000 and 11,000 vibrations per minute. The bottom face of the screeds shall be not less than 4 inches wide and shall be metal covered. The screeds shall have positive control of the vertical position.

4. Provide and use a suitable portable lightweight or wheeled work bridge behind the finishing operation.

CONSTRUCTION REQUIREMENTS

619.05 Limitations

On new structures, deck concrete shall be in place and properly cured before starting overlay operations. Overlay operations may begin as soon as the concrete has gained sufficient strength to resist damage from the blast cleaning.

Construct the overlay during favorable weather conditions. Preferably, place the mixture when the atmospheric temperature is between 55 and 75 °F; when the wind velocity is low; when the relative humidity is normal or high; and when hot conditions or rain are not expected. In all instances, place and keep the PMC overlay at a temperature above 45 °F for at least 96 hours after placement. Provide approved housing, heating, insulation methods, or some combination thereof, during cold weather. Do not place the mixture when the temperature is 85 °F or higher; when the wind velocity is high; when the relative humidity is extremely low; when rain is expected within the working period; or when any other atmospheric conditions cause difficulty in the satisfactory finishing, texturing, or curing of the overlay. This may require night work or other limited work periods. Keep PMC overlay aggregate and sand as cool as possible at the storage site during high temperatures to help prevent cracking in the new overlay.

619.06 Hydro-Demolition

Before placing the overlay, hydro-blast the concrete surface to be covered to the depth shown on the Plans. In areas where machine hydro-blasting cannot reach, in areas of spalling, and where steel reinforcement is exposed, remove deteriorated concrete to sound material using hand tools. Do not use pneumatic hammers heavier than a nominal 45 pounds.

After hydro-blasting, clear the deck of all debris. Do not allow traffic on the cleaned portion of the deck.

619.07 Cleaning

After hydro-blasting but before placing the overlay, power wash the entire area of the deck surface with a minimum 10,000-pound per square inch washing system to provide a bright, clean appearance that is free from laitance, dust, dirt, oil, grease, bituminous material, paint, and all other foreign matter. Perform the hydro-demolition of an area of the deck within the 24-hour period preceding the placement of the overlay on the area. Clean the existing deck using a process that will ensure conformance with the air and water pollution regulations applicable to the county or city where the site of work is located and with applicable safety and health regulations. Discontinue use of any method that does not consistently produce satisfactory work and conform to the above requirements, and replace with an acceptable method. While cleaning, reasonably confine all debris of every type, including dirty water, resulting from the cleaning operation. Immediately and thoroughly clean such debris from the blast-

cleaned surfaces and all other areas where any escaped debris may have accumulated.

Protect the cleaned areas, as necessary, against contamination before placing the overlay. Cover cleaned areas with a plastic cover that will be rolled up as the placement equipment passes over it so that the cleaned surface is not exposed to wheels, dirt, oil, grease, or any other contaminants. Re-clean contaminated areas and areas exposed more than 36 hours as directed by the Engineer at no cost to the Department.

619.08 Mixing

Mix concrete at the work site, where PMC is to be placed, in accordance with the specified requirement for the equipment used. Do not allow more than 5 minutes to elapse between the completion of mixing and the start of placement operations. Mixing capability shall be such that finishing operations can proceed at a steady pace with final finishing completed before the formation of the plastic surface film.

619.09 Placing, Consolidating, and Finishing

The Contractor may vibrate and finish using approved hand methods in areas that are not accessible to the finishing machine.

Place and fasten screed rails in position to ensure the new surface will be finished to the required profile. Anchorage for supporting rails shall provide horizontal and vertical stability. Do not treat screed rails with parting compound to facilitate their removal.

While placing the PMC, have two water vacuums present for removing excessive water.

Finished surface smoothness shall comply with **604.27**.

619.10 Texturing

Form transverse grooves in the concrete overlay by mechanical texturing. Form the grooves at an appropriate time during the stiffening of the concrete mixture so that in the hardened concrete, the grooves will be between 0.09 and 0.13 inches in width; between 0.12 to 0.19 inches in depth; and will be spaced at random intervals between 0.3 and 1 inch. The grooves shall terminate approximately 18 inches from curbs, concrete parapets, barrier walls, or other vertical walls. The grooves shall be

relatively smooth and uniform. Form the grooves without tearing the surface or without bringing pieces of the coarse aggregate to the top of the surface. Form grooves to drain transversely. Correct areas that do not conform to these requirements using approved methods at no cost to the Department.

619.11 Curing

Promptly cover the overlay surface with a single layer of wet burlap. Avoid using new burlap, as even when pre-soaked, it can dry out quickly. It may be necessary, at the Engineer's request, to wet the burlap and let it dry out, and then repeat this procedure several times to allow for total absorption. Use white plastic (visqueen) to cover the wet burlap.

Consistently spray a mist of water over the burlap before covering it with white plastic; however, ensure that the amount of water sprayed is not so excessive as to damage the fresh overlay surface.

Pull, place, and keep the white plastic within 10 to 30 feet of the front cover of burlap. Adjust these distances based on the weather conditions at the time of placement. Secure the plastic so that it will not blow off the burlap during the wet cure. Minimize the number of seams in the plastic.

Secure the plastic by using the rails, rolling over the edges of wet burlap onto the plastic, laying folded wet burlap transversely across the deck, or by keeping water on the surface of the plastic. Seal the plastic to prevent the wind from puffing up the plastic during the wet cure. Exercise caution when wetting down the surface of the plastic to prevent the water from running into the overlay being placed.

Place soaker hoses under the plastic once the overlay has set long enough to support the weight of the soaker hoses and after the overlay placement is completed. In hot weather, use cold water to enhance these procedures.

Take a random 1-quart sample of the latex off each concrete mobile supplier and deliver it to the Division of Materials and Tests lab for evaluation. An engineer from the office of Bridge Inspection and Repair shall be present for the initial calibration of the concrete mobile. The Engineer will check and measure the volume of the latex, cement, aggregate, and water at the concrete mobile before and after as an approximate check of the calibration of the concrete mixer.

Place a plastic cover over the deck area after the deck has received hydro-demolition and the deck area has been cleaned. Remove the plastic as the PMC is being placed.

619.12 Reconstruction

Remove all areas of the overlay that either display a significant number of cracks or that are not intimately bonded to the underlying deck, and replace with acceptable concrete at no cost to the Department. Seal all small cracks, which are not significant enough to require removal of the overlay, with a high molecular weight methacrylate sealant at no cost to the Department.

619.13 Traffic Loading

When Type I cement is used, do not allow traffic loading on the new PMC overlaid surface until it has undergone a 24-hour wet cure and 24-hour dry cure and has attained a compressive strength of 3,000 pounds per square inch.

When Type III cement is used, do not allow traffic loading on the new PMC overlaid surface until it has undergone a 12-hour wet cure and a 12-hour dry cure and has attained a compressive strength of 3,000 pounds per square inch.

COMPENSATION

619.14 Method of Measurement

The Department will measure PMC by the square yards in accordance with **109**.

The Department will measure PMC Variable Depth by the cubic yard complete in place, as determined by deducting the theoretical volume of Bridge Deck Overlay (PMC) from the total volume of PMC required to obtain the finished grade shown on the Plans or established by the Engineer.

619.15 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Bridge Deck Overlay (PMC)	Square Yard
Polymer Modified Concrete (Variable Depth)	Cubic Yard

Payment for Bridge Deck Overlay (PMC) is full compensation for placing and finishing the overlay, including providing all tools, labor, equipment, and incidentals for such placement. This item includes only the PMC for the theoretical plan depth of the overlay.

The Department will pay for accepted quantities of Polymer Modified Concrete (Variable Depth) at the invoice price of the materials delivered to the Project plus 5%. The invoice provided to the Department must reflect the producer's price used to establish the bid price for PMC and the total quantity of PMC purchased by the Contractor for the entire Project. All other costs associated with placing Polymer Modified Concrete (Variable Depth) are incidental to the price bid for Bridge Deck Overlay (PMC).

SECTION 620 – BRIDGE RAILINGS

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620.05 Method of Measurement 680
620.06 Basis of Payment 680

DESCRIPTION

620.01 Description

This work consists of furnishing and placing railings for bridges as covered by standard designs or as specially detailed, and also includes all reinforcing steel, anchor bolts, or insert sleeves as detailed to support the railing.

MATERIALS

620.02 Materials

For the respective type of railing, provide materials as follows:

Concrete Parapet with Structural Tubing	STD-11-1
Concrete Parapet	STD-1-1 or STD-1-1SS
Concrete Rail	STD-7-1, STD-11-2

620.03 Reserved

CONSTRUCTION REQUIREMENTS

620.04 Construction Methods

A. Metal Railing

Construct steel or aluminum tubing according to the details shown on the Plans and the requirements specified in **602**. Where painting is required, meet the requirements of **603.06**, unless otherwise specified. No painting will be required for aluminum or galvanized railing. Carefully adjust metal railing before bolting connections to ensure proper matching at abutting joints and correct alignment throughout the railing length. Set rail posts plumb, unless otherwise shown on the Plans.

B. Concrete Parapet and Concrete Railings

After all falsework has been struck, construct concrete parapet and concrete railings as specified in **604**. Exercise care to secure smooth and tight fitting forms that can be rigidly held to line and grade and removed without damaging the concrete. Construct all moldings, panel work, and bevel strips as shown on the Plans with neatly mitered joints. All corners in the finished work shall be true, sharp, and clean-cut and shall be free from cracks, spalls, or other defects. Give all exposed surfaces a Class II or Applied Textured Finish as specified in **604.21**.

COMPENSATION

620.05 Method of Measurement

The Department will measure bridge railing of the type specified, in place, by the linear foot, overall dimensions.

620.06 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Aluminum Railing (Description)	Linear Feet
Steel Railing (Description)	Linear Feet
Concrete Parapet (Description)	Linear Feet

Concrete Parapet with Structural Tubing	Linear Feet
Timber Railing (Description)	Linear Feet
Concrete Railing	Linear Feet

Such payment is full compensation for furnishing all materials and constructing the railing of the type specified complete in place.

SECTION 621 – TEMPORARY STRUCTURES

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621.02 Construction 682
621.03 Method of Measurement 683
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DESCRIPTION

621.01 Description

This work consists of constructing, maintaining, removing, and disposing of temporary structures and temporary shoring.

CONSTRUCTION REQUIREMENTS

621.02 Construction

Construct all temporary structures at the location and to the dimensions, grades, and load capacity shown on the Plans or in the Contract, or in accordance with drawings prepared by the Contractor and approved by the Engineer. Alternate design and details prepared by the Contractor must be equivalent to the design and details furnished by the Department. Prepare and submit alternate designs and details as specified in **105.02**.

Unless otherwise provided on the Plans or in the Contract, maintain temporary structures until the completion of the Contract or the opening of the permanent structure.

The maintenance of all temporary structures shall include their replacement in case of partial or complete failure. The Department reserves the right, in case of the Contractor's delay or inadequate progress in making repairs and replacement, to furnish such labor, materials and supervision of the work as may be necessary to restore the structure for proper movement of traffic. The Department will consider the entire expense of such restoration and repairs a part of the cost of the temporary structure and, where such

expenditures are incurred by the Department, will charge them to the Contractor.

Unless otherwise noted on the Plans or in the Contract, upon completion and opening to traffic of the permanent construction, remove and dispose of the temporary structure, restore the area as nearly as possible to its original condition, and leave the area in a neat condition satisfactory to the Engineer.

Use temporary shoring to retain earth during grading operations and bridge construction to maintain traffic. Install temporary shoring at the locations shown on the Plans or as directed by the Engineer. The Department will not make payment for this item when used for the installation of drainage structures and utilities, to meet OSHA regulations, or for the Contractor's convenience, unless these locations are specifically shown on the Plans. Design the temporary shoring for the specific locations and in-situ soil types. The submittal shall be in accordance with **105.02**, shall be stamped by a Professional Engineer, licensed in the State of Tennessee, and shall include detailed drawings, design calculations, and shoring material requirements. Temporary shoring may consist of sheet piling, piling/lagging walls, tie back walls, and similar structures.

COMPENSATION

621.03 Method of Measurement

The Department will measure temporary structures by the unit (per each), completed, accepted, and satisfactorily removed at the designated time.

The Department will measure and pay for temporary shoring by the square foot of exposed vertical face area. The bottom of shoring for payment will be where the exposed face intersects the existing or specified grade. The top of shoring for payment will be the actual shoring top, but not more than 1 foot above where the back of shoring intersects the existing or specified grade.

621.04 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Temporary Structure (Description – Station)	Lump Sum (per Each)
Temporary Shoring	Square Feet

Such payment is full compensation for all designs, submittals, labor, tools, equipment, materials, and all other incidentals necessary to install and remove temporary structures and temporary shoring.

Unless otherwise indicated, all salvageable material obtained from the removal and reconditioning work shall remain the property of the Contractor.

SECTION 622 – SHOTCRETE

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622.07 Mixing and Batching Shotcrete 690
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622.09 Method of Measurement 690
622.10 Basis of Payment 691

DESCRIPTION

622.01 Description

This work consists of constructing shotcrete in reasonably close conformance with the Plans or as established by the Engineer.

MATERIALS

622.02 Materials

Provide materials as specified in:

Portland Cement, Type I	**901.01**
Fine Aggregate	**903.01**
Coarse Aggregate	**903.22**
Water	**921.01**
Fly Ash	**921.15**

622.03 Proportioning and Quality Assurance of Shotcrete

A. Proportioning

Submit the proposed shotcrete design to the Engineer for approval. Establish the design using saturated surface dry aggregate weights and trial batches meeting the specified performance requirements. Make all strength determinations on equipment meeting the requirements of and in the manner prescribed by AASHTO T 22. Build trial batches and preconstruction test panels no more than 60 days prior to the design submittal. Assume responsibility for all costs related to concrete design, preparation, and submittal.

Include the following, as a minimum, in the proposed shotcrete design submittal:

1. Source of all aggregates
2. Brand and type of cement
3. Source and class of fly ash (if used)
4. Specific gravity of cement
5. Specific gravity of fly ash (if used)
6. Admixtures (if used)
7. Gradations of aggregates
8. Specific gravity of aggregates (saturated surface dry)
9. Percentage of fine aggregate of total aggregate (by volume)
10. Water-cement ratio (w/c)
11. Weights of each material required to produce a cubic yard of concrete
12. 3-day compressive strength (three 3-inch diameter cores taken from test panel or wall face)
13. 28-day compressive strength (three 3-inch diameter cores taken from test panel or wall face)
14. 7-day absorption (three 3-inch diameter cores taken from test panel or wall face)

Shotcrete shall meet the performance requirements specified in Table 622.03-1.

Table 622.03-1: Shotcrete Performance Requirements

Parameter	Value
3-Day Compressive Strength (psi)	2000
28-Day Compressive Strength (psi)	4000
Minimum Cementitious per cubic yard	660
Maximum Water/Cement (pound/pound)	0.45
Air Content (%)	7-10 (1)
7-Day Maximum Absorption (%)	8

(1) Air content acceptance range shall be between 7-10%, with sampling at the truck chute. Air entrainment is required for wet-mix shotcrete but not for dry-mix shotcrete.

Aggregate for shotcrete shall meet the strength and durability requirements of AASHTO M6/M80 and the gradation requirements specified in Table 622.03-2. An intermediate size aggregate may also be used as an additional component if needed to meet gradation.

Table 622.03-2: Gradation Requirements

Sieve Size	Percent Passing by Weight
1/2 inch	100
3/8 inch	90-100
No. 4	70-85
No. 8	50-70
No. 16	35-55
No. 30	20-35
No. 50	8-20
No. 100	2-10

Chemical admixtures to be incorporated into the shotcrete shall all be from the same manufacturer, and shall be incorporated into the shotcrete according to the manufacturer's recommendations, subject to the Engineer's approval. Ensure that accelerators (if used) are compatible with the cement used, are non-corrosive to steel, and will

not promote other detrimental effects such as cracking and excessive shrinkage.

B. Quality Control and Acceptance of Shotcrete

It is the Contractor's responsibility to determine and measure the batch quantities of all ingredients (including all water and specified or approved admixtures) for all shotcrete so that the shotcrete meets the specified requirements. During all batching operations, provide at the concrete plant a TDOT Concrete Level 2 or higher certified technician, who shall have the primary responsibility of process control, including all sampling, testing, and inspection of the aggregate and shotcrete.

The average compressive strength of each set of three test cores extracted from test panels or wall facing shall equal or exceed 85% of the specified compressive strength, with no individual core less than 75% of the specified compressive strength, as determined according to ACI 506.2. Do not take cores from the outer 6 inches of test panels, measured in from the top outside edges of the panel form. Trim the ends of compressive strength cores to provide test cylinders that are at least 3 inches long. Do not trim ends for absorption cores.

Provide all equipment, materials, and personnel necessary to obtain shotcrete cores for testing, including constructing test panel boxes, field curing, and coring. The Engineer will perform compressive strength and boiled absorption testing, and will base shotcrete final acceptance on 28-day compressive strength.

622.04 Preconstruction Test Panels

Furnish two preconstruction test panels for each proposed mixture being considered and for each shooting position to be encountered on the Project. Make preconstruction test panels prior to production and as part of the mix design submittal process, using the same equipment, materials, mixture, proportions, and procedures proposed for the work.

Construct the preconstruction test panels with minimum dimensions of 30 x 30 inches square and at least 4 inches thick. Slope the sides at 45 degrees over the full panel thickness of release rebound.

Construct one preconstruction test panel to include the maximum anticipated reinforcing congestion shown on the Plans. Cores extracted

from the test panel shall demonstrate encapsulation of the reinforcement in accordance with ACI 506.2 equal to core Grade 2 or better.

Construct the second preconstruction test panel without reinforcement, and extract nine 3-inch diameter cores for absorption and compressive strength testing.

622.05 Production Test Panels

Provide a minimum of one production test panel or, instead of production test panels, nine 3-inch diameter cores taken from the shotcrete facing during the first production application of shotcrete and henceforth for every 5,000 square feet of shotcrete placed. Cut at least nine 3-inch diameter core samples from each production test panel for absorption and compressive strength testing.

If choosing to take cores from the wall face instead of making production test panels, take cores at the locations designated by the Engineer. Fill core holes in the wall facing by dry packing with non-shrink patching mortar after cleaning and dampening the holes. Do not fill core holes with shotcrete.

Construct production test panels simultaneously with the shotcrete facing installation at times designated by the Engineer. Production test panels shall be a minimum full thickness of 18 x 18 inches square and at least 4 inches thick.

The Contractor may extract test specimens from test panels in the field or may transport them to another location for extraction. Keep panels in their forms during transport.

622.06 Test Panel Curing and Testing

Immediately after shooting the test panels, field moist cure the panels by covering and tightly wrapping with a sheet of material meeting ASTM C171 until they are delivered to the testing lab or test specimens are extracted. Do not immerse test panels in water. Do not further disturb test panels for the first 24 hours after shooting.

Clearly mark preconstruction/production cores and containers to identify core locations. If for production testing, mark the section of the wall represented by the cores on the cores and container. Immediately wrap cores in wet burlap or material meeting ASTM C171, and seal in a plastic

bag. Deliver cores to the Engineer or testing lab, as directed by the Engineer, within 48 hours of shooting the panels. When the test length of a core is less than twice the diameter, the correction factors given in AASHTO T24 will be applied to obtain the compressive strength of individual cores. The remainders of the panels shall become the property of the Contractor.

622.07 Mixing and Batching Shotcrete

Aggregate and cement may be batched by weight or by volume in accordance with AASHTO M 241 (ASTM C685). Ready mix shotcrete shall comply with AASHTO M157. Batch, deliver, and place shotcrete within 90 minutes of mixing. The use of retarding admixtures may extend application time beyond 90 minutes if approved by the Engineer.

Premixed and packaged shotcrete mix may be provided for on-site mixing. The packages shall contain materials conforming to **622.02**. Place the material within the time limit following mixing recommended by the manufacturer.

EQUIPMENT

622.08 Equipment

Use mixing equipment that thoroughly blends the materials in sufficient quality to maintain placing continuity.

COMPENSATION

622.09 Method of Measurement

The Department will measure completed and accepted quantities of shotcrete in square feet, by taking measurements over and parallel to the actual area of the applied shotcrete.

622.10 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Shotcrete	Square Feet

Such payment is full compensation for furnishing all labor, materials, tools, equipment, and incidentals required to place the shotcrete, including surface preparation.

SECTION 623 – BRIDGE EXPANSION JOINTS

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DESCRIPTION

623.01 Scope of Work

This work consists of fabricating and installing shop fabricated bridge expansion joint systems, of the general size, configuration, and joint movement specified.

623.02 Modular Roadway Expansion Joints

This Subsection is applicable to expansion joints having a required movement in excess of 4 inches.

A. Fatigue Design

Provide certification that all proposed modular expansion devices have been tested in accordance with the National Research Program Report 467 *Performance Testing for Modular Bridge Joint Systems*.

B. Materials

1. **General.** All parts and elements shall be of the material and design indicated in the manufacturer's catalog, except as otherwise specified in the Contract or shown on the Plans.

2. **Steel Plates, Bars, Rolled Shapes, and Extrusions.** All steel plates, bars, rolled shapes, and extrusions shall be fabricated from high-strength, low alloy grade 50S, HPS50W steel, conforming to the requirements of ASTM A709 grade 50 or 50W, as shown on

approved shop drawings. Anchor bars may be A36 steel. All membrane retainers shall have a 3/8-inch minimum thickness.

Stainless steel sheets for the sliding surfaces of the support bars shall conform to the requirements of ASTM A167, alloy 304, 20 micro-inch RMS finish.

Anchor bolts, bolts, nuts, and washers shall conform to the requirements of ASTM F1554, as shown on the Plans.

3. **Preformed Elastomeric Seals.** The elastomeric sealing element shall be a polychloroprene (neoprene) seal that is resistant to heat, oil, jet fuel, and ozone. The seal shall be one piece full length of the expansion joint, including curb and parapet face projections.

   In addition, the sealing elements shall conform to ASTM D2628, modified to omit the recovery test and to meet the requirements specified in Table 623.02-1.

Table 623.02-1: Elastomeric Sealing Element Hardness

Property	Requirement	ASTM Method
Hardness Type A	60 +/- 7 Durometer	D2240 Modified

   To install the preformed elastomeric elements in place, use as a lubricant/adhesive a one-part moisture-curing, polyurethane and hydrocarbon solvent mixture or as recommended by the manufacturer and approved by the Engineer.

4. **Support Bar Bearings.** Use support bar bearings fabricated from polyurethane compound with polytetrafluorethylene (PTFE) self-lubricating surfaces having engineering properties equivalent to adiprene, teflon or cast nylon w/MDS (molybdenum disulfide) (i.e., high-load bearing and high-impact resistance characteristics plus low coefficient of friction).

5. **Joint Control Mechanism.** To ensure equal distribution of the total joint opening, provide suitable equilibrium type springs that operate counter to compression forces of the sealing elements and co-linear with the axis of structure movement.

6. Support Bars. Provide support bars that as a minimum:

a. Incorporate stainless steel sliding surfaces to minimize resistance to joint movements.

b. Provide support above, below, and laterally as required to prevent lifting, transmit bearing loads, and maintain positioning of the bar. Place support bars at right angles to each transverse rail.

c. Are at least 2 inches in width and 3 inches in height, and that will ensure that each transverse rail (separation beam) will rest on a separate support bar at each support assembly.

7. Separation Beams/Transverse Dividers. Separation beams/transverse dividers shall be at least 2-1/2 inches in top width and 4 inches in height and shall be designed for the design live load (AASHTO HS 20-44 minimum plus 50% for impact), using working stress limits. Analyze support bars and transverse rails using both vertical and horizontal live load components.

8. Miscellaneous Hardware. Provide miscellaneous hardware as described in the manufacturer's literature.

C. Fabrication and Construction

The manufacturer of the prefabricated expansion joint assembly shall prepare shop drawings showing details of the assembly and installation. Installation drawings shall include concrete, reinforcing steel and/or anchorage details falling within the respective modular joint stress zones.

1. Construct the expansion joint systems as shown on the shop drawings. Meet the tolerance requirements included in AASHTO specifications. Perform all welding according to AWS specifications and by certified welders only. Ensure that fabricators are certified under the AISC Quality Certification, Category I, Simple Steel Bridges, SBR-1B.

2. Shop drawings shall also supply information regarding material specifications, geometry, a table of variable temperature and dimensions, and a bill of material. The

maximum joint opening for a single modular unit shall be 4 inches measured at right angles to the rails.

3. With the exception of the stainless steel elements, either paint all steel in accordance with System A as specified in **603.06**, or galvanize it, unless otherwise shown on the Plans.

4. Ensure that the profile of the joint in the pavement area conforms to the roadway cross-section, slope, skew, and grade. Provide slider plates at curbs, walkways, and parapets, as part of the completed joint assembly, in accordance with details shown on the Plans and Standard Drawings.

5. Preset the modular expansion joint assembly in accordance with approved shop drawings, joint setting data, and specifications. Secure the assembly for shipping. Provide the assembly with temporary self-aligning guide angles or other structural members to span over the block-out for joints and allow for proper grade and elevation adjustment between the bridge deck and approach roadway. Make final adjustment at the discretion of the Engineer. Account for all movements due to factors such as shrinkage, creep, and mid-slab deflection, before making this final adjustment. Obtain the permission of the joint manufacturer's technical representative to make any adjustments other than for temperature settings.

6. Properly position and attach the prefabricated joint assembly to the superstructure using the anchorages provided with the assembly.

7. Do not use drilled and grouted or cast-in-place inserts to anchor the expansion device to the structure. Accomplish anchorage by attachment to each longitudinal bridge girder, supplemented by 2-inch wide straps, providing no less than 1.25 square inches of cross-sectional area per linear foot of expansion joint between direct connections at girders. The straps shall be a minimum length of 1 foot with a 2-inch, 90-degree bend at the free end.

8. Ensure that girder attachments provide a means of adjustment so that the expansion device can be installed to line and grade in conformance with approved shop drawings, the Plans, and the manufacturer's recommendations.

9. Use a similar configuration for the backwall anchorage.

10. Coordinate with the joint supplier, remain-in-place form supplier, and/or beam fabricator to ensure that all details impacting the acceptable installation of the expansion joint are in harmony.

11. Clean formed recesses of foreign material, and prepare by an approved method. Ensure that deck concrete is well consolidated behind and around both sides of the joint edge rails and support boxes.

D. Installation Supervision and Certification

A manufacturer's representative shall be present at the time of installation to assist the Contractor in the proper setting of the joint. If the individual representing the manufacturer is not a full time employee of the manufacturer, provide written certification that the individual is a duly authorized agent of the manufacturer before beginning joint installation. After installation, the representative shall inspect and certify to the Engineer that the joint has been installed in accordance with the manufacturer's recommendations, and that it is water-tight. The Engineer will not accept joints for which such certifications are not provided.

The Contractor and the manufacturer's representative shall conduct tests for water-tightness in the presence of the Engineer by ponding water upon the joint for a period of 15 minutes. Take corrective measures to eliminate all leaks.

623.03 Strip Seal Expansion Joints

A. Description of Work

This subsection is applicable to expansion joints having a required movement of 4 inches or less.

B. Materials

1. **General.** All parts and elements shall be of the material and design indicated in the manufacturer's catalog, except as otherwise specified in these provisions or shown on the Plans.

2. **Steel Plates, Bars, Rolled Shapes, and Extrusions.** All steel plates, bars and shapes shall be fabricated from high-strength, low alloy Grade 50 steel, conforming to the requirements of ASTM A709 Grade 50 or 50W, as shown on approved shop drawings. Anchor bars and plates may be A36 steel. The membrane retainer may be either an extrusion or rolled shape.

   Anchor bolts, bolts, nuts, and washers shall conform to the requirements of ASTM A307, as shown on the Plans.

3. **Preformed Elastomeric Seals.** The elastomeric sealing element shall be EPDM or a polychloroprene (neoprene) seal that is resistant to heat, oil, jet fuel, and ozone. The seal shall be one piece full length of the expansion joint including curb and parapet face projections. The seal shall be a mechanically locked seal element placed in a solid steel extrusion or rolled shape conforming to the Plans dimensions.

   In addition, the sealing elements shall conform to ASTM D2628, modified to omit the recovery test and to meet the requirements specified in Table 623.02-1 above.

   To install preformed elastomeric elements in place, use as a lubricant/adhesive a one-part moisture-curing, polyurethane and hydrocarbon solvent mixture or as recommended by the manufacturer and approved by the Engineer.

4. **Miscellaneous Hardware.** Provide miscellaneous hardware as described in the manufacturer's literature.

C. Fabrication and Construction

1. The manufacturer of the prefabricated expansion joint assembly shall prepare shop drawings showing details of the assembly and installation. Installation drawings shall include concrete, reinforcing steel and/or anchorage details falling within the respective joint zones. The shop drawings shall also show any changes to the reinforcing steel or concrete limits from the Plans due to the type joint being used.

2. Shop drawings shall also supply information regarding material specifications, geometry, a table of variable temperature and dimensions, and a bill of material. The maximum joint opening

shall be 4 inches. Construct the expansion joint systems in accordance with the details shown on the shop drawings. Tolerance requirements shall be in accordance with AASHTO Specifications. Perform all welding in accordance with AWS specifications and by certified welders only. Ensure that fabricators are certified under the AISC Quality Certification, Category I, Conventional Steel Structures.

3. Ensure that the profile of the joint conforms to the roadway cross-section, slope, skew, and grade.

4. Either paint all steel that is part of the joint assembly in accordance with System A as specified in **603.06**, or galvanize in accordance with ASTM A123, unless shown otherwise on the Plans.

5. Properly position and attach the prefabricated joint assembly to the superstructure using the anchorages provided with the assembly.

6. Do not use drilled and grouted or cast-in-place inserts to anchor the expansion device to the structure on new construction. Accomplish anchorage by attachment to each longitudinal bridge girder, supplemented by 2-inch wide straps, providing no less than 1.25 square inches of cross-sectional area per linear foot of expansion joint between direct connections at girders. The straps shall be a minimum length of 1 foot with a 2-inch, 90-degree bend at the free end.

7. Anchorage details for repair of expansion joints on existing structures shall be as shown on the Contract drawings and/or approved shop drawings.

8. Ensure that girder attachments provide a means of adjustment so that the expansion device can be installed to line and grade in conformance with approved shop drawings, the Plans, and the manufacturer's recommendations.

9. Use a similar configuration for the backwall anchorage.

10. Coordinate with the joint supplier, remain-in-place form supplier, and/or beam fabricator to ensure that all details impacting the acceptable installation of the expansion joint are in harmony.

11. Clean formed recesses of foreign material and prepare by an approved method. Ensure that deck concrete is well consolidated behind and around both sides of the joint steel.

COMPENSATION

623.04 Method of Measurement

The Department will measure expansion joints of each kind horizontally by the linear foot along the center of the joint from outer face to outer face of the concrete superstructure of the bridge.

The Department will consider slider plate assemblies at curbs, walkways, medians, median barriers, and parapets to be incidental to the items for the expansion joint systems, and will not measure and pay for them directly.

623.05 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Modular Roadway Expansion Joints	Linear Feet
Strip Seal Expansion Joints	Linear Feet

A. Modular Roadway Expansion Joints

Payment for Modular Roadway Expansion Joints is full compensation for furnishing and installing the device complete in place, including all labor, materials, equipment, and other incidentals necessary to complete the work.

The Department will pay for the deck concrete placed within the limits of the expansion joint block-outs at the applicable contract unit price per cubic yard. Otherwise, the cost of all modifications of bridge details, including parapet and/or median slider plate assemblies, forming for adequate block-outs of the concrete deck slab, and any additional reinforcing steel required in the concrete deck slab block-outs, necessary to properly install the roadway expansion joint shall be included in the price bid for the joint.

B. Strip Seal Expansion Joints

Payment for Strip Seal Expansion Joints is full compensation for furnishing and installing the device complete in place, including all labor, materials, equipment, and other incidentals necessary to complete the work.

Modifications of bridge details including parapet and/or median slider plate assemblies that are necessary to properly install the roadway expansion joint shall be included in the price bid for the joint.

PART 7 – INCIDENTAL CONSTRUCTION AND SERVICES

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SECTION 701 – CEMENT CONCRETE SIDEWALKS, DRIVEWAYS AND MEDIAN PAVEMENT

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DESCRIPTION

701.01 Description

This work consists of constructing, on a prepared subgrade, Portland cement concrete Sidewalks, Driveways, and Median Pavement, excluding those Sidewalks, Driveways, and Median Pavement that are integrally part of structures.

MATERIALS

701.02 Materials

Provide materials as specified in:

Preformed Joint Filler **905.01**

Cement Concrete Curing Materials **913**
Drain Pipe, Standard Strength **914.04**

To construct sidewalks, driveways, and median pavement, use Class A concrete meeting the requirements of **604**.

EQUIPMENT

701.03 Equipment

A. Forms

Use forms of wood, metal, or other suitable material. Extend forms for the full depth of the concrete. Only use forms that are true to line, free from warp, and of sufficient strength to resist the pressure of the concrete without springing. On all radial sections, use curved forms of proper radius and that are of a design acceptable to the Engineer. Brace and stake forms to ensure that they will remain in both horizontal and vertical alignment until their removal.

B. Mixing and Finishing Equipment

Use mixers that meet **501.04.B**.

Furnish satisfactory floats, templates, straightedges, edgers, spades, and tamps. Compact the subgrade using tamping or rolling equipment that will produce the desired results.

Instead of using forms, the Contractor may use a slip form paver that is capable of producing the required results.

CONSTRUCTION REQUIREMENTS

701.04 Preliminary Work

Perform Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction as specified in **201**, **202**, **203**, and **205**, respectively.

701.05 Subgrade Preparation

Prepare subgrade for sidewalks, driveways, and median pavement to the required depth and to a width that will allow for the installation and bracing of the forms. Shape and compact the subgrade to a firm, even surface in reasonably close conformity with the grade and cross-section shown on the Plans. Remove all soft and yielding material, replace it with acceptable material, and compact it as directed by the Engineer.

701.06 Expansion Joints

Unless otherwise shown on the Plans or directed by the Engineer, place premolded expansion joint filler, 1 inch in thickness, at the locations and in line with expansion joints in the adjoining pavement, gutter, or curb. Cut all premolded expansion joint filler to the full width or length of the proposed construction, and extend it to within 1 inch of the top or finished surface. Place all longitudinal expansion joints as shown on the Plans or as directed by the Engineer. Ensure that all expansion joints are true, even, and present a satisfactory appearance.

Form construction joints around all appurtenances, such as manholes and utility poles, that extend into and through the sidewalk or median area. Install 1-inch thick premolded expansion joint filler in these joints. Install expansion joint filler, of the thickness shown on the Plans, between concrete sidewalks and any fixed structure, such as a building or bridge. Install 1-inch thick expansion joint filler between concrete curb and median pavement and, unless otherwise specified, between concrete curb and sidewalk. This expansion joint material shall extend for the full depth of the walk or median pavement.

701.07 Limitations on Mixing

Comply with **501.11**.

701.08 Mixing and Placing Concrete

Mix concrete as specified in **604.14**.

Place concrete as specified in **501.12**, except that mechanical spreaders will not be required. Immediately before placing the concrete, thoroughly wet the subgrade, and give the forms a coating of light oil. Thoroughly clean and oil the forms before each use.

701.09 Finishing

Strike-off the concrete with a transverse template resting upon the side forms. After striking-off the concrete to the required cross-section, finish it with floats and straightedges until the required surface requirements have been obtained.

When the concrete surface is free from water and just before the concrete obtains its initial set, finish and lightly sweep the surface with a broom to produce a sandy texture. The longitudinal surface variations shall not exceed 1/4 inch under a 12-foot straightedge, or 1/8 inch on a 5-foot transverse section. Ensure that the finished concrete surface will drain completely at all times.

Carefully finish the edges of the sidewalks, driveways, and median pavement, and round with an edging tool having a 1/2-inch radius.

Divide the surface of sidewalks into blocks using a grooving tool. Space the grooves approximately 5 feet apart and to produce rectangular blocks unless otherwise directed by the Engineer. Cut the grooves to a depth of not less than 1 inch. Shape the edges of the grooves with an edging tool having a 1/4-inch radius.

Place grooves in median pavement to be in line with corresponding joints in adjoining construction or as directed by the Engineer.

Unless otherwise shown on the Plans, place marks or grooves at right angles to the center-line of driveways and approximately 8 inches apart. Using a suitable marking tool, make these markings to be between 1/8 and 1/4 inch in depth. A grooving tool, of 6 to 8 inches in width, with multiple grooves for grooving alternate strips 8 inches apart, may be used for this purpose. Remove irregularities caused by the edges of the marking tool using a wetted brush or wooden float. Round all marking edges.

Do not place grooves in the surface of sidewalks or driveways reinforced for beam action where the full thickness of concrete is required for strength.

Round the edges of the concrete at expansion joints with an edging tool having a 1/4-inch radius. Remove all marks caused by edging. Clean the top and ends of expansion joint material of all concrete, and trim the expansion joint material so as to be slightly below the surface of the concrete.

701.10 Protection and Curing

Forms may be removed as soon as their removal will not damage the concrete. Do not exert pressure upon the concrete when removing forms.

Perform curing and provide cold weather protection as specified in 501.18.

Do not allow pedestrians on concrete sidewalks, driveways, or medians until 12 hours after finishing the concrete. Do not allow vehicles or loads on any sidewalk, driveway, or median until the Engineer has determined that the concrete has attained sufficient strength for such loads.

Construct and place barricades and protection devices as necessary to keep pedestrians and other traffic off the sidewalk, driveway, or median.

Repair all sidewalks, driveways, or paved medians damaged prior to final acceptance of the Project, at no cost to the Department, by removing concrete within groove limits and replacing it with concrete of the same type and finish as used in the original construction.

701.11 Backfilling

Immediately after removing the side forms, fill the spaces along the edges of the sidewalk or driveway with suitable material, placed in layers not exceeding 4 inches in loose thickness, and compact this material until firm and stable.

701.12 Final Cleanup

Perform final cleanup as specified in **104.10**.

COMPENSATION

701.13 Method of Measurement

The Department will measure Concrete Sidewalks and Concrete Driveways by the square foot, complete in place, based on surface area measurements. Where standard widths are constructed, the measurements shall not exceed the standard widths shown on the Plans without the Engineer's written approval. The Department will measure Concrete Sidewalks of each thickness, and Concrete Driveways, separately.

The Department will measure Concrete Median Pavement by the volume in cubic yards, complete in place, as obtained from the specified thickness shown on the Plans and surface measurements for width and length.

The Department will measure Concrete Handicap Ramps by the area in square feet, complete in place, as obtained from surface measurements. Where standard widths are constructed, the measurements shall not exceed the standard widths shown on the Plans, unless approved in writing by the Engineer.

Unless otherwise shown on the Plans, the Department will consider subgrade preparation, backfill, expansion joint materials, and drain pipe to be incidental to the work.

701.14 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Concrete Sidewalk (__ ")	Square Feet
Concrete Driveway (__ ")	Square Feet
Concrete Median Pavement	Cubic Yard
Concrete Handicap Ramp	Square Feet

Such payment is full compensation for all subgrade preparation, backfill, and all other incidentals necessary to complete the work.

SECTION 702 – CEMENT CONCRETE CURB, GUTTER, AND COMBINED CURB AND GUTTER

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DESCRIPTION

702.01 Description

This work consists of constructing Curb, Gutter, or Combined Curb and Gutter of Portland cement concrete.

MATERIALS

702.02 Materials

Provide materials that meet the applicable requirements of **604** and **913**, and as specified in:

Preformed Joint Filler	**905.01**
Drain Pipe, Standard Strength	**914.04**

To construct curb, gutter, and combined curb and gutter, use Class A concrete meeting the requirements of **604**, with the following exception: when placing concrete with a curb extruding machine, the slump shall range from 0 to 3 inches.

The Contractor may adjust water and percentages of fine and coarse aggregate within the limits specified (fine aggregate may range from 40 to 65%) to allow satisfactory placement.

The Department will make compressive strength test specimens by the vibratory method in accordance with AASHTO T 23 or other methods.

EQUIPMENT

702.03 Equipment

A. Forms

Except for the templates between 10-foot sections, use either wood or metal forms that meet **701.03.A**. For the templates, use 1/8-inch thick metal, of the same width as that of the curb, gutter, or combination curb and gutter, and that is not less than 1/4 inch more in depth than the respective depth of the type curb and gutter being constructed. The templates shall have lugs or other devices to hold them in position during concrete placement and shall be of a design that will allow their removal without damaging the concrete. For gutters, use a strike-off template, of the form and shape of the gutter, to shape the top surface of the gutter.

B. Compaction Equipment

Compact the subgrade using tamping or rolling equipment that will produce the desired results.

C. Mixing and Finishing Equipment

Use mixers that meet **501.04.B**. With the Engineer's approval, the Contractor may use a curb machine that will place the concrete in a satisfactory manner. Provide finishing equipment, including satisfactory floats, edgers, spades, and tamps.

CONSTRUCTION REQUIREMENTS

702.04 Preliminary Work

Perform Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction as specified in 201, 202, 203, and 205, respectively.

702.05 Subgrade Preparation

Perform subgrade preparation for curb, gutter, and combined curb and gutter to the required depth, and to a width that will allow the installation and bracing of the forms. Shape and compact the subgrade to a firm, even surface, in reasonably close conformity with the grade and section shown on the Plans. Remove all soft and yielding material, replace it with acceptable material, and compact as directed by the Engineer.

702.06 Expansion Joints

Form expansion joints at the intervals and locations shown on the Plans, using 1-inch thick preformed joint filler, unless otherwise specified. Place expansion joints in line with corresponding expansion joints in adjoining pavement or other construction. Cut joint filler to the full cross-section of the curb, gutter, or curb and gutter.

702.07 Limitations on Mixing

Comply with 501.11.

702.08 Mixing, Placing, and Finishing Concrete

Mix concrete as specified in 604.13.

Immediately before placing the concrete, thoroughly wet the subgrade, and apply a coating of light oil to the forms. Thoroughly clean and oil the forms before each use.

Place concrete as specified in 501.12, except that the mechanical spreader will not be required.

Place the concrete immediately after mixing. Spade and vibrate the edges, sides, or faces to thoroughly consolidate the concrete and bring the mortar

to the surface. After vibrating, use a wooden float to give the surface a smooth and even finish.

Construct concrete curb, gutter, or combined curb and gutter, to be reasonably true to line, grade, and cross-section, and, unless otherwise shown on the Plans, in sections having uniform lengths of 10 feet. The length of these sections may be reduced to no less than 6 feet where necessary for closures. Carefully set the templates before placing the concrete, and keep them in place until the concrete has set sufficiently to hold its shape. Remove templates while the forms are still in place. Remove the forms on the face of all curbs as soon as the concrete will hold its shape, and then use a wooden float on the surface to provide a smooth and even finish. No plastering is permitted. Unless otherwise specified, round the top edges of the curb and the edge of the gutter to a radius of 3/4 inch. Finish the edges on each side of templates and expansion joint material with an edging tool having a radius of not over 1/4 inch, and then remove all lines or marks with a wet brush. Finish the back of curbs not less than 3 inches below the top of backfill against the curb. Leave all exposed surfaces, against which some rigid type of construction is to be made, smooth and uniform so as to allow free movement of the curb, gutter, or combined curb and gutter.

Remove all tool marks with a wetted brush or wooden float, and ensure that the finished surface presents a uniform and pleasing appearance.

If the Engineer allows use of curb machines, perform finishing as specified above, except that instead of constructing the curbs in sections, contraction joints may be sawed a minimum depth of 1/4 the thickness of the section, at intervals of 6 to 10 feet.

Place weep holes or drainage openings through curbs as shown on the Plans or as directed by the Engineer. Place coarse aggregate behind each opening as needed.

702.09 Protection and Curing

Immediately after finishing the concrete, provide protection and perform curing as specified in **501.18**.

Protect the curb, gutter, and combined curb and gutter until final acceptance. Repair concrete that is damaged before final acceptance by removing and reconstructing each 10-foot section that has been damaged at no cost to the Department.

702.10 Backfilling

Immediately after the concrete has set sufficiently and the forms have been removed, fill the space behind the curb or combined curb and gutter with suitable material, placed in layers not exceeding 4 inches in loose thickness, and compact until firm and stable.

702.11 Final Cleanup

Perform final cleanup as specified in **104.10**.

COMPENSATION

702.12 Method of Measurement

The Department will measure Concrete Curb, Concrete Gutter, and Concrete Combined Curb and Gutter for payment by the cubic yard, complete in place. The volume, per linear foot of length, will be obtained from the dimensions shown on the Plans. Linear measurements will be surface measurements taken along the center of gravity of the section.

Unless otherwise shown on the Plans, the Department will consider subgrade preparation, backfill, expansion joint materials, and drain pipe to be incidental to the work.

The Department will not measure or make payment under this Section for curb integral with concrete pavement or concrete base unless otherwise shown on the Plans or specified in the Contract.

702.13 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Concrete Curb	Cubic Yard
Concrete Gutter	Cubic Yard
Concrete Combined Curb and Gutter	Cubic Yard

Such payment is full compensation for all subgrade preparation, backfill, and all other incidentals necessary to complete the work.

SECTION 703 – CEMENT CONCRETE DITCH PAVING

703.01 Description 713
703.02 Materials 713
703.03 Equipment 714
703.04 Preliminary Work 714
703.05 Subgrade Preparation 714
703.06 Joints 715
703.07 Limitations on Mixing 715
703.08 Mixing, Placing, and Finishing Concrete 715
703.09 Protection and Curing 715
703.10 Backfilling 715
703.11 Final Cleanup 715
703.12 Method of Measurement 716
703.13 Basis of Payment 716

DESCRIPTION

703.01 Description

This work consists of constructing paved ditches of Portland cement concrete on a prepared subgrade.

MATERIALS

703.02 Materials

Provide materials that meet the applicable requirements of 604.

For Portland cement concrete ditch paving, use Class A concrete meeting the requirements of 604.

EQUIPMENT

703.03 Equipment

A. Forms

Use forms of either wood or metal that meet **701.03.A**. To shape the top surface of the paved ditch, use a strikeoff template having the same form and shape as the ditch section.

B. Compaction Equipment

Compact the subgrade using tamping or rolling equipment that will produce the required compaction and shape.

C. Mixing and Finishing Equipment

Use mixers that meet **501.04.B**. Mechanical ditch paving machines may be used when approved by the Engineer.

Provide finishing equipment, including satisfactory floats, edgers, spades, and tamps.

CONSTRUCTION REQUIREMENTS

703.04 Preliminary Work

Perform Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction as specified in 201, 202, 203, and 205, respectively.

703.05 Subgrade Preparation

Prepare subgrade for ditch paving to the required depth and to a width that will allow the installation and bracing of forms. Shape and compact the subgrade to a firm, even surface, in reasonably close conformity with the grade and section shown on the Plans or as directed by the Engineer. Remove all soft and yielding material, replace it with acceptable material, and compact as directed by the Engineer.

703.06 Joints

Form joints at the intervals and locations shown on the Plans. Cut joint filler for expansion joints to the full depth of the ditch pavement.

703.07 Limitations on Mixing

Comply with **501.11**.

703.08 Mixing, Placing, and Finishing Concrete

Mix concrete as specified in **604.13**.

Before placing concrete, prepare the subgrade and forms as specified in **701.05**.

Place the concrete immediately after mixing. After spading the edges and allowing the concrete to thoroughly consolidate, use a wooden float to give the surface a smooth and even finish.

Round the edges of the paved ditch to a radius of 1/2 inch, and finish edges along expansion and contraction joints with an edging tool having a radius of not over 1/4 inch. Remove all edging tool marks with a float and brush.

703.09 Protection and Curing

Immediately after finishing the concrete, cure it as specified in **501.18**.

Protect the ditch paving until final acceptance of the Project. Remove concrete that is damaged prior to acceptance by removing and reconstructing the damaged sections at no cost to the Department.

703.10 Backfilling

Immediately after the concrete has set sufficiently and the forms have been removed, fill the spaces on each side of the ditch paving with suitable material and compact thoroughly; or, if sod is specified, lay it in accordance with **803**.

703.11 Final Cleanup

Perform final cleanup as specified in **104.10**.

COMPENSATION

703.12 Method of Measurement

The Department will measure Portland Cement Concrete Ditch Paving for payment by the cubic yard, complete in place. The volume per linear foot of length will be obtained from the dimensions shown on the Plans. Linear measurements will be surface measurements taken along the center-line of the paved ditch.

Unless otherwise shown on the Plans, the Department will consider subgrade preparation, backfill, and expansion joint materials to be incidental to the work.

703.13 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Portland Cement Concrete Ditch Paving	Cubic Yard

Such payment is full compensation for all subgrade preparation, backfill, and all other incidentals necessary to complete the work.

SECTION 705 – GUARDRAIL

705.01 Description 717
705.02 Materials 717
705.03 Reserved 718
705.04 Preliminary Work 718
705.05 Posts 718
705.06 Installation of Posts 718
705.07 Erection 720
705.08 Final Cleanup 720
705.09 Method of Measurement 720
705.10 Basis of Payment 721

DESCRIPTION

705.01 Description

This work consists of furnishing and erecting guardrail, and constructing anchor blocks and approach ends, of the specified kind and dimensions.

Guardrail includes appurtenant materials and work required to make connections with other guardrail or structures, as may be required to complete the Work shown on the Plans.

MATERIALS

705.02 Materials

Provide materials as specified in:

Metal Beam Guardrail	**909.05**
Guardrail Posts	**909.07**
Guardrail Hardware	**909.08**

Use Class A Portland cement concrete. Mix, place, finish, and cure concrete as specified in 604.

For all guardrail safety End Treatment systems, provide certification from the supplier that the device is an NCHRP 350 or AASHTO Manual for Assessing Safety Hardware (MASH) approved product, as documented in an acceptance letter from FHWA. Attach, to the certification, the acceptance letter stating that the proposed device complies with NCHRP 350 or MASH for the appropriate test level. In addition, submit detailed shop drawings for the NCHRP 350 or MASH approved devices to the Engineer, and keep a copy onsite during installation.

705.03 Reserved

CONSTRUCTION REQUIREMENTS

705.04 Preliminary Work

Perform Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction as specified in 201, 202, 203, and 205, respectively.

705.05 Posts

Provide posts of the shape, size, and dimensions shown on the Plans and/or the approved Shop Drawings. Set posts reasonably true to the lines and grades shown on the Plans or established by the Engineer.

705.06 Installation of Posts

Before beginning any excavation or driving any guardrail post, determine the location of all underground electrical, drainage, and utility lines in the vicinity, and conduct work so as to avoid damaging these facilities. Dig or drill holes to the depth shown on the Plans and/or the approved Shop Drawings and to a size that will allow proper setting of the posts and sufficient room for backfilling and tamping. Alternatively, the Contractor may drive posts using approved methods and equipment, provided the posts are erected in the proper position and are free of distortion, burring, or other damage.

If solid rock is encountered while drilling post holes:

1. Within 18 inches of the ground surface, drill an oversized or elongated hole 24 inches into the rock. Set the post at the roadside edge of the hole, and backfill the hole with the cutting spoils.

a. If using wooden posts, either drill a single oversized hole 23 inches in diameter, or three overlapping holes 10 inches in diameter, to a length of 23 inches.

b. For steel posts, drill a single oversized hole, 20 inches in diameter, or three overlapping holes 8 inches in diameter, to a length of 20 inches.

2. Below 18 inches of the ground surface, drill holes 12 inches into the rock or to the depth shown on the Plans. The holes shall be 8 inches in diameter for steel posts, and 12 inches in diameter for wood posts.

3. When installing end terminals using tubes, install posts 1 and 2 to full depth or a minimum of 36 inches into the solid rock. Backfill the holes around the steel tube with the cutting spoils.

4. See approved shop drawings for additional information concerning post depth and hole size.

To validate proper installation of posts, for each guardrail contractor/installer doing work for the Department, the Department will pull a minimum of five line posts and five terminal posts per Region per year for verification of length. The Regional Construction and Materials and Tests offices may select any post for verification, but at a minimum, will select posts from five different runs of rail. If the posts are found to be in accordance with the Plans and Specifications, the Contractor may re-install the posts if they were not damaged during the pulling process. If the post length is found to be deficient, the Department will require the contractor/installer to remove the entire run of guardrail or end terminal and replace it properly at no cost to the Department.

Backfill holes with selected earth or other suitable materials in layers not to exceed 4 inches in thickness. Thoroughly tamp each layer. After backfilling and tamping is complete, hold the posts or anchors securely in place.

For metal divider guardrail on bridges, bolt posts to the structure as shown on the Plans. Set the anchor bolts to the proper location and elevation, with templates, and carefully check after the median is placed and before the concrete has set.

Set anchor bolts for metal divider guardrail, to be placed on a previously constructed bridge, by drilling holes in the proper locations and anchoring the bolts as shown on the Plans.

Repair damaged coating on galvanized steel posts as specified in **713.04.B**, or replace the posts, at the Engineer's direction, at no cost to the Department.

705.07 Erection

Set guardrail anchors, and make and place attachments as shown on the Plans and/or approved Shop Drawings, or as directed by the Engineer. Guardrail installed on new alignments is to be complete in place before the mainline roadway is opened to traffic unless otherwise directed by the Engineer. On roadways open to traffic, install each section of guardrail complete in place including end sections in a continuous operation.

Draw up tightly all bolts or clips used for fastening the guardrail or fittings to the posts. End bolts shall have sufficient length to extend at least 1/4 inch through and beyond the full nut, except where such extension might interfere with or endanger traffic, in which case, cut off the bolt flush with the nut.

Erect, draw, and adjust all railings so that the longitudinal tension will be uniform throughout the entire length of the rail.

Shop curve Metal Deep Beam Single Guardrail and Protective Guardrail at Bridge Ends that are installed on a curve with a radius of 150 feet or less.

705.08 Final Cleanup

Perform final cleanup as specified in **104.10**.

COMPENSATION

705.09 Method of Measurement

The Department will measure Guardrail of the various classes and dimensions in accordance with the Plans.

The Department will measure Terminal Anchors of the various types for payment by the unit within the limits shown on the Plans.

The Department will not measure projections or anchors beyond the end post for payment, except as noted.

The Department will consider excavation and backfilling, and the furnishing and placing of anchor bolts and devices for guardrail posts on bridges, to be incidental to the work.

705.10 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Guardrail (Class)	Linear Feet
Guardrail End Terminal (Type)	Each
Single Guardrail (Type)	Linear Feet
Guardrail at _____	Linear Feet

The Department will make no payment for a section of guardrail, including end terminals, until it is complete in place. Payment is full compensation for all posts, blocks, rail elements, terminal sections, fittings, hardware, labor and equipment, and all incidentals necessary to complete the work.

When no contract unit price has been established for Shop Curved Metal Deep Beam Single Guardrail, payment will be made at a rate equal to 1.5 times the contract unit price for Metal Deep Beam Single Guardrail with corresponding post spacing. When no unit price has been established for Shop Curved Protective Guardrail at Bridge Ends, payment will be made at a rate equal to 1.25 times the contract unit price of Guardrail at Bridge Ends.

No additional payment will be made for shop curving the guardrail in the Guardrail End Terminal units.

When no contract unit price has been established for drilling or boring in solid rock for posts while placing Single Guardrail or End Terminal Posts, the Department will pay for each hole at a rate equal to 2.0 times the contract unit price for Single Guardrail. When no pay item for Single Guardrail exists in the Contract, payment will be made at a rate of 2.0 times the current yearly State average.

While drilling or boring into solid rock for posts placed in conjunction with Guardrail at Bridge Ends, Parapets, Piers, Concrete Endposts, and other

similar edifice, payment will be made at a rate equal to 1.25 times the contract unit price per applicable end device.

No additional payment will be made for drilling or boring for the placement of posts, unless posts are driven to refusal in solid rock.

SECTION 706 – GUARDRAIL ADJUSTED, REMOVED AND RESET

706.01 Description 723
706.02 Materials 723
706.03 Reserved 724
706.04 Preliminary Work 724
706.05 Dismantling or Removing Guardrail 724
706.06 Installation of Posts 725
706.07 Erection 725
706.08 Guardrail Adjustment 725
706.09 Final Cleanup 725
706.10 Method of Measurement 725
706.11 Basis of Payment 726

DESCRIPTION

706.01 Description

Guardrail Adjusted or Removed and Reset consists of dismantling, removing, salvaging, resetting, or adjusting existing guardrail, as shown on the Plans or as directed by the Engineer. The work includes the furnishing of all necessary hardware, anchors, and other appurtenances required to replace those that are not suitable for reuse.

Posts Furnished and Guardrail Furnished consists of furnishing and setting guardrail and posts to replace rail and posts that are unsuitable for resetting, as shown on the Plans or as directed by the Engineer. Guardrail removed and reset shall comply with the Department's Standard Drawings and/or approved Shop Drawings, as applicable for the type of installation.

MATERIALS

706.02 Materials

Provide materials as specified in:

Guardrail Posts..... **909.07**

Remove, dismantle, reshape, repair, and reset all materials that can be reused.

For the reset rail, use salvaged material for posts, rails, cables, wire, metal sheets or plates, and similar features, but furnish whatever additional bolts, clips, and other appurtenances of the kind and quality used in the original guardrail as may be required to complete the guardrail.

Posts, rail and hardware furnished and set shall be of the size and type used in the original guardrail, or as shown on the Plans, and/or approved Shop Drawings, and shall meet the requirements of **909.05**, **909.07**, and **909.08**.

706.03 Reserved

CONSTRUCTION REQUIREMENTS

706.04 Preliminary Work

Perform Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction as specified in **201**, **202**, **203**, and **205**, respectively.

706.05 Dismantling or Removing Guardrail

Carefully dismantle and detach railings, anchors, fittings, and all other material suitable for reuse from the posts, and neatly store and protect from damage.

Do not remove any sections of existing guardrail until the Engineer concurs the removal is necessary and the appropriate warning devices are installed. Promptly install the proposed guardrail, including any anchor system, to minimize traffic exposure to hazards.

Excavate or pull all posts so as not to damage the posts for further use.

Inventory, clean, and store all salvaged material until it is reset.

Replace, at no cost to the Department and with material of the same type and kind, all material damaged or lost on account of carelessness, negligence, or failure to properly protect the material and perform the work.

Remove broken posts or stubs and dispose of as directed by the Engineer.

706.06 Installation of Posts

Install posts as specified in 705.06.

The Engineer will designate which posts are to be reused.

706.07 Erection

Thoroughly clean all posts and guardrail to be reset.

Space posts as originally spaced, unless otherwise shown on the Plans. Set posts vertically, and to the depth shown on the Plans or as established by the Engineer.

For all other details of erection, comply with 705.07.

706.08 Guardrail Adjustment

Perform guardrail adjustment or realignment as shown on the Plans and in accordance with these Specifications and the following definitions:

Realigned Guardrail: Sections of guardrail that may be realigned without removal or disassembly and are not out of line horizontally ±6 inches or vertically ±2 inches.

Adjusted Guardrail: Guardrail that may be repositioned by the vertical adjustment of the block.

Resetting Guardrail: Entire sections of guardrail that require removal as directed by the Engineer.

706.09 Final Cleanup

Perform final cleanup as specified in **104.10**.

COMPENSATION

706.10 Method of Measurement

The Department will measure for payment:

1. Guardrail Removed, Guardrail Reset, and Guardrail Adjustment by the linear foot along the center-line of the guardrail, and from center of end post to center of end post.

2. Guardrail Furnished by the linear foot along the center-line of the rail before installations.

3. Posts Furnished by the individual unit.

4. End terminals in accordance with 705.09 and 705.10.

The Department will not measure projections or end terminals beyond the end post, or any excavation or backfilling performed in connection with this construction.

706.11 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Guardrail Removed	Linear Feet
Guardrail Reset	Linear Feet
Guardrail Removed and Reset	Linear Feet
Guardrail Adjustment	Linear Feet
Posts Furnished	Each
Guardrail Furnished	Linear Feet

Payment for Guardrail Adjustment, Guardrail Removed, and Guardrail Reset is full compensation for all additional bolts, clips, and other incidentals required to complete the work.

SECTION 707 – FENCES

707.01 Description 727
707.02 Materials 727
707.03 Reserved 728
707.04 Preliminary Work 728
707.05 Setting Posts and Backfilling 728
707.06 Erecting Fence 729
707.07 Final Finishing and Cleanup 730
707.08 Method of Measurement 730
707.09 Basis of Payment 731

DESCRIPTION

707.01 Description

This work consists of constructing fences, gates, and water crossings.

MATERIALS

707.02 Materials

Provide materials of the kind, size, and type shown on the Plans, including all necessary posts, fittings, and appurtenances.

Provide materials as specified in:

Portland Cement Concrete, Class A	**604**
Stock Fence	**909.01**
Chain-Link Fence	**909.02**
Fence Gates	**909.03**
Water Gates and Water Crossings	**909.04**

The Engineer will reject galvanized material that is damaged. With the Engineer's approval, the Contractor may repair damaged galvanized material as specified in **713.04.B**.

707.03 Reserved

CONSTRUCTION REQUIREMENTS

707.04 Preliminary Work

Before beginning construction or placing of fences, perform all necessary Clearing and Grubbing and Removal of Structures and Obstructions as specified in 201 and 202, respectively. Clearing for fence construction shall not extend beyond the right-of-way line. Do not disturb living trees and shrubs 1 foot or more on each side of the fence line unless otherwise directed by the Engineer. Locate the fence 1 foot inside the right-of-way unless otherwise shown on the Plans. Remove rock, which protrudes above the ground surface and is in the line of the fence, to the ground surface.

Turn fences in at drainage structures, cattle passes, and bridges where directed by the Engineer so as to abut wingwalls and abutments.

Provide two weeks notice to affected property owners before cutting existing fences. Install access control fences before cutting existing fences in areas used by domestic livestock or other areas as directed by the Engineer.

707.05 Setting Posts and Backfilling

Set line posts for stock fence at intervals not to exceed 10 feet. Erect braced line posts at intervals of 330 feet between end or corner posts, and, when necessary due to terrain features, install additional braced line posts at locations designated by the Engineer. Measure the interval between posts parallel to the bottom of the fabric of the proposed fence and in line of fence from center to center of post.

Set posts for chain-link fence at intervals not to exceed 10 feet. Measure the intervals between posts as specified above for stock fence.

Install posts, shown on the Plans to be set in concrete, in dug or drilled holes of the size and to the depth shown on the Plans or directed by the Engineer. For embedment of posts and for anchors, use Class A concrete meeting the requirements of 604. Construct the concrete embedment and anchors with a crown at the top to shed water.

If ground conditions allow, the Contractor may drive posts that do not require embedment to the required depth using approved methods, or otherwise shall install such posts in holes dug or drilled to the specified depth and to a size that will allow sufficient room for proper backfilling.

If solid rock is encountered, install posts by drilling the rock to the required depth and grouting the post therein with Portland cement grout composed of one part cement to three parts sand.

Backfill post holes for posts not requiring concrete embedment with selected earth or other approved material. Place backfill material in layers not exceeding 6 inches, and thoroughly tamp each layer. When backfilling and tamping is completed, secure the posts and anchors in the proper position.

Do not apply pull to posts set in concrete until the concrete has cured a minimum of 72 hours.

707.06 Erecting Fence

At certain locations along the right-of-way, the Engineer will direct the Contractor to construct chain-link fence or stock fence prior to the removal of existing fences.

When fences are constructed 1 foot inside the right-of-way, landowners may join these fences by setting posts adjacent to them.

A. Stock Fences

Place fabric by securing or fastening one end and applying sufficient tension to remove approximately one-half of the tension curve in the wire before making permanent attachment elsewhere. Fasten the fabric and barbed wire to the posts as shown on the Plans. Tightly draw up all bolts and clips or ties used to fasten wire or fittings to the posts. Use bolts of sufficient length to extend at least 1/4 inch through and beyond the full nut; however, where such extension might constitute a safety hazard, cut the bolt off flush with the nut.

B. Chain-Link Fence

Place the fabric by securing one end and applying sufficient tension to remove all slack before making attachment elsewhere. Fasten the fabric to the posts at intervals not exceeding 14 inches. When

specified, connect the top rail with expansion sleeves to form a continuous rail, and fasten the fabric to the rail at intervals not exceeding 2 feet. When using aluminum-alloy fabric, attach a tension wire to the bottom of the fabric by means of a hog-ring type fastener at a maximum of 2-foot intervals, and secure the wire at the terminal posts with brace bands.

Pull barbed wire taut before permanently attaching to a post or extension arm.

When chain-link or stock fences cross short depressions or ditches, construct water crossings or water gates of the type, at the locations, and in accordance with the Plans or as directed by the Engineer.

Construct and install fence gates as shown on the Plans or as directed by the Engineer.

707.07 Final Finishing and Cleanup

The Engineer will inspect fences after they have been placed in final position. Dispose of all excess or unsuitable material as directed by the Engineer.

Perform final cleanup as specified in **104.10**.

COMPENSATION

707.08 Method of Measurement

The Department will measure:

1. Fences by the linear foot along the bottom of the fabric and from end to end of the fence, complete in place, deducting the width of openings.

2. Gates by the unit, per each, complete in place, for the kinds and dimensions as shown on the Plans.

3. Water Crossings, complete in place, by the length in linear feet, as determined in accordance with the details shown on the Plans.

4. Water Gates, complete in place, by the area in square feet, as determined in accordance with the details shown on the Plans.

5. End, braced line, and corner post assemblies as determined in accordance with the details shown on the Plans and the following:

    a. Chain Link Fence: The Department will measure each assembly consisting of one post and one or more horizontal rails and one or more truss rods, as detailed on the Plans by the unit.

    b. Stock Fences: The Department will measure each assembly consisting of one post, diagonal or horizontal braces and tie wires as detailed on the Plans, by the unit.

The Department will consider excavation, backfilling, and concrete for anchors and post embedment to be incidental to the work.

The Department will not measure projections or anchors beyond the end posts for payment.

707.09 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Fence (Description)	Linear Feet
Gate (Description)	Each
End, Braced Line, and Corner Post Assemblies (Description)	Each
Water Crossings	Linear Feet
Water Gates	Square Feet

Such payment is full compensation for all excavation, backfill, and all other incidentals necessary to complete the work.

SECTION 708 – MONUMENTS AND MARKERS

708.01 Description 732
708.02 Materials 732
708.03 Equipment 733
708.04 Foundation Preparation 733
708.05 Manufacture and Erection of Monuments and Markers 734
708.06 Final Finishing and Cleanup 734
708.07 Method of Measurement 735
708.08 Basis of Payment 735

DESCRIPTION

708.01 Description

This work consists of furnishing and erecting monuments or markers composed of Portland cement concrete or other materials approved by the Engineer. Monuments and Markers shall be of the kind, size, dimensions, shapes, and markings as shown on the Plans.

MATERIALS

708.02 Materials

Furnish monuments and markers manufactured of Class A concrete, composed of materials including reinforcement meeting 604.02.

Provide concrete right-of-way markers that have a smooth finish and are fabricated as shown on the Plans.

Stone for monuments and markers shall meet **921.07**.

Metal materials shall conform to the requirements shown on the Plans or specified in the Special Provisions.

Provide paint, if required, that meets 910 for the kind and type of paint called for on the Plans.

EQUIPMENT

708.03 Equipment

Provide hoisting equipment, rollers, skids, protecting mats, and other equipment necessary to handle monuments or markers without damage.

CONSTRUCTION REQUIREMENTS

708.04 Foundation Preparation

A. Monuments

Unless otherwise shown on the Plans, excavate for monuments to not less than 6 inches larger on all sides than the base of the monument, and to a depth of not less than 6 inches below the grade of the base of the monument, unless solid rock is encountered. Remove all soft or yielding material in the foundation to such depth as directed by the Engineer, and refill and tamp in 6-inch layers with material satisfactory to the Engineer.

If solid rock is encountered, excavate to below the grade of the base, remove soft or flaky material, and bring to a true even grade.

Ensure that the foundations for all monuments are of such character as will hold the monument in place and in its intended position. Obtain the Engineer's approval of the foundation.

B. Markers

Prepare the excavation for markers by digging holes to the depth shown on the Plans or as directed by the Engineer, and of such size as will allow satisfactory backfilling and tamping. If rock is encountered above the grade of the base of the marker, the Contractor may cut off the marker, provided it is set 1 foot in solid rock and the area around the marker is filled with Class A concrete or mortar meeting 905.02. Place the backfill in 6-inch layers. Thoroughly tamp each layer, and

when the backfilling is completed, ensure that the marker is substantial and unyielding.

708.05 Manufacture and Erection of Monuments and Markers

Concrete monuments and markers may be precast or cast-in-place. The concrete shall meet the requirements of **604.03** for Class A concrete. Manufacture monuments and markers in accordance with the applicable provisions of **604**.

Cut stone monuments and markers from stone conforming to **921.07** and to be of the size and shape and to contain such other details as shown on the Plans or as directed by the Engineer.

Place markers in the prepared excavation, and hold firmly in place, true to line and grade, until backfilled. Place backfill in 6-inch layers, and thoroughly tamp each layer.

Install or erect stone or precast monuments on the prepared foundation, set accurately at the proper elevation, and in a manner that will ensure they will remain firmly in place. Set the monuments on blocks or shims to line and grade. Fill the excavation below the bottom of the monument with Class A concrete. Work the concrete in, under, and around the base of the monument until all voids are filled. After the concrete has set, backfill the remainder of the excavation to the natural ground line with suitable material.

Perform painting, if called for on the Plans, as specified in **603**.

708.06 Final Finishing and Cleanup

The Engineer will inspect monuments or markers after they have been placed in their final position. Remove all defects and scars.

Neatly shape the surface of the ground immediately around each installation to the established grade. Dispose of all excess material as directed by the Engineer.

Perform final cleanup as specified in **104.10**.

COMPENSATION

708.07 Method of Measurement

The Department will measure Monuments and Markers for payment by the number of individual units furnished, placed, and accepted, complete in place.

The Department will consider excavation and foundation preparation, and the backfill material and concrete used in preparing foundations or backfilling the excavation, to be incidental to the work.

708.08 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Monuments (Description)	Each
Markers (Description)	Each

Such payment is full compensation for all labor, materials, equipment, and all other incidentals necessary to complete the work.

SECTION 709 – RIPRAP AND SLOPE PAVEMENT

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DESCRIPTION

709.01 Description

Riprap consists of furnishing and setting or placing rubble stones, crushed stone, sacked sand-cement, machined riprap, and embedded riprap.

Slope Pavement consists of constructing a reinforced concrete mat on prepared slopes.

MATERIALS

709.02 Materials

To construct riprap and slope pavement, provide materials that meet the following:

A. Rubble-Stone Riprap

For Rubble-Stone Riprap, provide stone or broken Class A or paving concrete meeting the requirements of **921.07**. Ensure that at least 80% of the stone have a minimum dimension of 10 inches. The remainder shall be 2 to 4 inches, and shall be approximately rectangular or trapezoidal in shape. Broken Class A or paving concrete shall be free of steel and wire fabric reinforcement.

For Rubble-Stone Riprap (Grouted), provide sand meeting **903.01** or **903.02** and cement meeting **901.01**.

B. Sacked Sand-Cement Riprap

For Sacked Sand-Cement Riprap, provide manufactured or natural sand meeting the quality requirements of **903.01** or **903.02** and cement meeting **901.01**.

Use sacks of either cotton or jute, standard grade of cloth, that will hold the sand-cement mixture without leakage during handling and tamping. Sacks shall be strong and sized to hold approximately 1 cubic foot.

C. Reinforced Concrete Slope Pavement

Construct reinforced concrete slope pavement of Class A concrete meeting **604.03** and steel reinforcement meeting **907.01** or **907.03**, whichever is specified.

Preformed expansion joint filler shall meet **905.01**.

D. Curing Materials

Provide materials meeting **913**.

E. Machined Riprap

For Machined Riprap, provide clean shot rock that is essentially free of sand, dust, and organic materials, and that is of the size designated for the class specified. The stone shall be uniformly distributed throughout the size range. Construct the stone layer to the thickness designated for the specified class, as defined in **709.03**, unless otherwise noted on the Plans.

Provide washed or clean rock, at no additional cost to the Department, for sensitive areas of the Project, as shown on the Plans, described in permits, or designated by the Engineer. Obtain the Engineer's approval of washed or clean rock before placing in environmentally sensitive areas.

When using rock or stone as riprap, ensure that the material, when subjected to five alternations of the sodium sulfate soundness test (AASHTO T 104), does not have a weighted percentage of loss of more than 12. Obtain the Engineer's approval of the material before using.

709.03 Classification

Riprap is classified according to the following designations:

1. Rubble-Stone Riprap (Grouted)

2. Sacked Sand-Cement Riprap

3. Machined Riprap

    a. Machined Riprap (Class A-1) shall vary in size from 2 inches to 1.25 feet with no more than 20% by weight being less than 4 inches. The thickness of the stone layer shall be 1.5 foot with a tolerance of 3 inches.

    b. Machined Riprap (Class A-2) shall be identical to Class A-1 except that the Contractor may substitute hand placed rubble stone riprap placed 1 foot thick in accordance with **709.11** for 1.5 feet of machined riprap.

    c. Machined Riprap (Class A-3) shall vary in size from 2 to 6 inches with no more than 20% by weight being less than 4 inches. The thickness of the 4-inch stone layer shall be as shown on the Plans.

    d. Machined Riprap (Class B) shall vary in size 3 inches to 2.25 feet with no more than 20% by weight being less than 6 inches. The thickness of the layer shall be 2.5 feet with a tolerance of 4 inches.

e. Machined Riprap (Class C) shall vary in size from 5 inches to 3 feet with no more than 20% by weight being less than 9 inches. The thickness of the layer shall be 3.5 feet with a tolerance of 6 inches.

EQUIPMENT

709.04 Equipment

Provide wooden or metal tamps of sufficient weight and number to properly compact the slopes on which the riprap or slope pavement is to be placed.

When using sacked sand-cement, furnish wooden hand tamps, having a tamping face not greater than 1 square foot, and of sufficient weight and number to properly tamp the riprap.

To mix concrete, cement grout, or sand-cement, provide a mechanical mixer, or, if the Engineer approves hand-mixing for cement grout, a water-tight mixing platform or mixing box of adequate size.

Provide all necessary small tools or implements to perform the work.

CONSTRUCTION REQUIREMENTS

709.05 Foundation Preparation

Immediately before constructing riprap or slope pavement, trim the slopes or ground surface within reasonably close conformity to the lines and grades shown on the Plans or as directed by the Engineer, and thoroughly compact the slopes or ground surface using hand or mechanical tamps.

On slopes, place the bottom of the riprap at least 2 feet below the natural ground surface, unless otherwise directed by the Engineer.

709.06 Rubble-Stone Riprap (Grouted)

A. Placing Stone

Construct Rubble-Stone Riprap (Grouted) by hand on the prepared foundation. Place the stones as close together as is practicable to minimize voids.

When constructing rubble-stone riprap in layers, tie the layers together using large stones protruding from one layer into the other.

Construct rubble-stone riprap to a standard depth of 12 inches, unless otherwise shown on the Plans or directed by the Engineer, but in no case to less than 10 inches in depth. Ensure that, for each 25 square feet of surface, Rubble-Stone Riprap has an average depth of not less than the depth shown on the Plans or as directed by the Engineer, or the standard depth required in these Specifications.

Place each stone with the larger dimension parallel to the surface upon which it is set, except as set forth above to provide keys between layers. Place the length as directed by the Engineer, and set each main stone against the adjoining stones to provide close contact. Place stone so as to equally distribute the large stones to the extent possible.

After a workable area of the riprap has been set, shape the stones by knapping to a uniform surface. Thoroughly chink the voids and fill with the smaller stones and spalls. Continue this work as construction progresses.

B. Grouting

After chinking and filling, fill the voids between the stones with grout. Take care to prevent earth or sand from filling the spaces between the stones before the grout is poured.

To fill the voids, use grout composed of one part Portland cement and four parts sand, measured by volume, and mixed thoroughly with sufficient water to make a grout of a consistency that will flow into and completely fill the voids.

Mix this grout either in a one-bag mixer or larger for not less than 1-1/2 minutes, or mix it by hand in a watertight box of sufficient capacity to accommodate a batch of at least one bag of cement. Continue to hand mix in a manner and for a period satisfactory to the Engineer.

Immediately before pouring the grout, sprinkle the stones with water. Pour the grout carefully into the voids between the stones, beginning at the lower portions of the riprap and progressing upward. Ensure that the entire bottom line of voids is filled with grout before pouring the line of voids next above. To pour the grout, use vessels of adequate

size and shape. Broadcasting, slopping, or spilling of grout from the vessels on the surface of the riprap will not be permitted. Progress of pouring shall be sufficiently slow to prevent the grout from oozing from the voids and flowing over the surface. During the pouring operations and continuing until the grout has reached its initial set, use fiber brooms to maintain a uniform distribution. Continue the grouting operations until all the voids have been completely filled and the grout has set even with the surface of the riprap.

C. Curing

As soon as any section of the grouted riprap has hardened sufficiently, sprinkle it with water until the riprap has been covered with burlap, cotton, or jute mates, earth, or liquid membrane-forming compound. Maintain the mats or earth by soaking with water for a period of not less than 72 hours. The water used for wetting and curing the grouted riprap shall be free from salt or alkali.

709.07 Sacked Sand-Cement Riprap

Construct Sacked Sand-Cement Riprap by placing sacks, filled approximately 3/4 full with a mixture of sand and cement, on the prepared foundation.

Mix the sand and cement dry, with a mechanical mixer, in the proportion of 94 pounds of cement to 5 cubic feet of dry sand, until the mixture is uniform in color. After the mixing has been completed, pour the sand-cement mixture into sacks, of approximately 1-cubic foot capacity, until they are approximately 3/4 filled. Securely fasten the sacks with hog rings, by sewing, or by using other suitable methods that prevent leakage of the mixture from the bags.

Bed the sacks of sand-cement, by hand, on the prepared grade with all the fastened ends on the grade and with the joints broken. The completed riprap shall have a minimum thickness of 10 inches, measured perpendicular to the slope. The surface shall not vary more than 3 inches above or below the desired theoretical plane.

Ram and pack the sacks against each other, and tamp on the surface to form close contact and to ensure a uniform surface. Immediately after placing and tamping the sacks of sand-cement, thoroughly soak them by sprinkling with water. Do not apply water under high pressure.

Before soaking with water, remove and replace sacks of sand-cement that were ripped or broken during placing.

709.08 Reinforced Concrete Slope Pavement

Construct Reinforced Concrete Slope Pavement as shown on the Plans and in accordance with the applicable requirements of **604**, except that the concrete shall be of such consistency that it will not flow on the slope and that will allow finishing to the thickness shown on the Plans.

Score or saw the slope pavement for a depth of 1 inch on 6-foot centers, both ways, or as directed by the Engineer. Use a 1/2-inch preformed expansion joint filler wherever the slope pavement abuts a portion of the bridge sub-structure.

Remove forms, which may be of wood or metal, after the concrete has set. Cure the concrete as specified in **501.18.**

709.09 Machined Riprap

Take care in preparing the riprap subgrade to ensure that no reduction in the design waterway occurs. Do not place any riprap until the final subgrade elevation has been verified by the Engineer. When directed by the Engineer, roll the riprap down with metal tracked equipment to provide a more dense stone mass with final contours in reasonable conformance to the Plans. Do not begin to place the super-structure until the Engineer has accepted the final elevation of the riprap.

Upon completion of the work, visually inspect to ensure that approximately 50% of the surface area consists of stones no smaller than half of the maximum size specified.

Dump and place the material using appropriate power equipment in a manner that will produce a uniform surface appearance. Hand work may be required to correct irregularities.

When preparing the site, adhere to the provisions for erosion control specified in **209** and for channel excavation specified in **203.02.C**.

When required by the Plans or permits, or as directed by the Engineer, properly tamp into the subsurface, or otherwise blend into the substrate, embedded riprap in streams, conveyances, diversions, or other sensitive areas. Ensure that water will flow over the embedded riprap and that flow

is not lost below or within the rock. If clean rock is required by the Plans or permit, or as directed by the Engineer, provide rock that meets the provisions of **709.02** for clean rock.

709.10 Final Cleanup

Perform final cleanup as specified in **104.10**.

COMPENSATION

709.11 Method of Measurement

The Department will measure Rubble-Stone Riprap (Grouted), Concrete Block Riprap, and Reinforced Concrete Slope Pavement by the volume in cubic yard, complete in place, as obtained from the thickness shown on the Plans and surface measurements. Unless otherwise specified, the Department will not measure or pay for reinforcement in slope pavement, but will consider the costs thereof as included in the price bid for slope pavement.

The Department will measure Machined Riprap by the ton or the cubic yard for the respective items in accordance with **109**, complete in place. However, where Machined Riprap (Class A-2) is specified and the Contractor selects the hand placed rubble stone riprap option, the Department will increase actual tonnage measured and accepted by 50% for payment purposes.

No measurement for payment will be made for excavation or for preparing the foundation for riprap, and filter blanket where specified.

709.12 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Rubble-Stone Riprap	Cubic Yard or Ton
Rubble-Stone Riprap (Grouted)	Cubic Yard
Concrete Block Riprap	Cubic Yard
Reinforced Concrete Slope Pavement	Cubic Yard

709.12

Machined Riprap (Class __)	Cubic Yard or Ton

SECTION 710 – UNDERDRAINS

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DESCRIPTION

710.01 Description

This work consists of constructing underdrains composed of stone, gravel, slag, sand, or any one of these materials and perforated pipe, semi-circular drain pipe (with connections), or filter cloth, on prepared foundations at the locations shown on the Plans or as directed by the Engineer. The work shall include all necessary excavation and backfill, together with such work and materials as may be necessary to make connections with other drainage structures, as shown on the Plans.

MATERIALS

710.02 Materials

Provide materials as specified in:

Aggregate for Underdrains **903.17**
Joint Mortar **905.02**
Pipe (Size shown on the Plans)..... **914.03**, **914.07**, **915.02, 915.03**
Polyvinyl Chloride (PVC) Underdrain Pipe **914.09**
Geotextile..... **921.12**

710.03 Kinds and Sizes of Underdrains

Construct underdrains of the kinds specified. Unless otherwise specified, circular pipe for underdrains shall have a diameter of 4 inches. Semi-circular pipe for underdrains shall have a diameter of 4-5/8 inches. In the case of pipe, consider the size to mean the nominal inside diameter.

710.04 Reserved

CONSTRUCTION REQUIREMENTS

710.05 Aggregate Underdrains

Excavate trenches to receive the aggregate at the locations and to the dimensions shown on the Plans or as directed by the Engineer. Make the trench deep enough to intercept the water-bearing strata, and provide it with a smooth and uniform finish.

Place aggregate meeting the requirements of 903.17 in the trench in 6-inch layers to the depth shown on the Plans. Tamp each layer with an approved tamp.

Do not construct any underdrains that will not be paved over during the same construction season.

710.06 Aggregate Underdrains (with Pipe)

Excavate the trench to receive the pipe at the locations shown on the Plans or as directed by the Engineer. If the Plans do not show dimensions, construct the width of the trench to be not less than the outside diameter of the pipe plus 12 inches. Make the trench deep enough to intercept the water-bearing strata and to allow installation of the pipe and cover material. Unless otherwise shown on the Plans, spread a 2-inch layer of aggregate on the bottom of the trench, compact it, and bring to a uniform grade.

Ensure that the pipe is firmly embedded in the layer of aggregate. Lay perforated pipe with the flow sector and perforations at the bottom.

If an underdrain is extended through a dry fill or other section where perforated pipe is undesirable, construct the underdrain with the pipe specified, and join sections by forming mortar joints or approved manufactured joints, or by using connecting bands.

After the pipe has been laid and approved, carefully backfill around the pipe with the specified aggregate in a manner that will not displace the pipe. Place the aggregate around and over the pipe in 6-inch layers. Thoroughly tamp each layer with a vibratory compactor.

Make lateral and other connections where shown on the Plans or as directed by the Engineer.

710.07 Filter Cloth and Aggregate Underdrain (with and without Pipe)

A. Trench Excavation

Excavate trenches at the locations and to the depth and width shown on the Plans. Prepare the sides and bottom of the trenches to a relatively smooth condition, free of sharp objects, obstructions, depressions, and debris that might damage the filter cloth during installation.

Dispose of material removed from the trench outside of the right-of-way at locations obtained by the Contractor unless the Engineer authorizes its disposal within designated locations.

B. Filter Cloth

Place geotextile meeting **921.12** with the long dimension parallel to the center-line of the channel, laying it loosely without wrinkles or creases. When more than one width of filter cloth is necessary, overlap the joints a minimum of 12 inches. Insert securing pins with washers through both strips of overlapped material and into the material beneath, until the washer bears against the cloth and secures it firmly to the base material. Insert these securing pins through the overlapped cloth at not greater than 2-foot intervals along a line through the midpoint of the overlap.

Protect the cloth at all times during construction to prevent contamination by surface runoff. Remove contaminated cloth and replace with uncontaminated cloth at no cost to the Department. Replace cloth damaged during installation at no cost to the Department. Drop stone for overlaying on the cloth from a height no greater than 3 feet. Place the cloth so that the downstream edges overlap the upstream edges.

Install the filter cloth so that all splice joints are provided with a minimum overlap of 3 feet. Overlap the closure at the top of the trench

as shown on the Plans, and secure with mechanical ties. Where outlet pipe passes through the fabric, use a separate piece of fabric of sufficient size to be wrapped around the pipe and flared against the side of the filled drain fabric.

Anchor field splices of filter cloth with securing pins as directed to maintain the required overlap. Take care when placing the aggregate filler and installing the pipe (when specified) to prevent damage to the filter cloth. To repair a torn, punctured, or otherwise damaged section, cut a piece of filter cloth large enough to cover the damaged area and overlap all around the damaged area a minimum of 12 inches.

C. Aggregate Underdrain

Place the aggregate in 6-inch layers, and compact each layer using a vibratory compactor to the satisfaction of the Engineer before making the filter cloth closure at the top of the trench. Protect the exposed end of the outfall pipe by an endwall matching the existing slope.

Bevel the end of the outfall pipe to fit the slope of the endwall. Should the outlet end of the pipe or the endwall fall within the limits of ditch paving, remove to neat lines that portion of the ditch paving within the endwall limits necessary to provide a connection with the new endwall, and make the endwall blend with the ditch paving.

710.08 Final Cleanup

Dispose of all excess or unsuitable material as directed by the Engineer. Perform final cleanup as specified in **104.10**.

COMPENSATION

710.09 Method of Measurement

The Department will measure for payment:

1. Aggregate Underdrains by the linear foot along the centerline of the underdrains, and from end to end of the underdrains, complete in place.

2. Filter Cloth Underdrains and Filter Cloth Underdrains (With Pipe) by the linear foot along the centerline of each type of Underdrain (with or without pipe) actually installed.

3. Lateral Underdrain by the linear foot, as measured along the center of the outfall pipe from the center of the Filter Cloth Underdrain to the centroid of the beveled outfall end.

4. Lateral Endwalls by the unit, per each, for the type and size as indicated on the Plans.

5. Six-inch Perforated Pipe with Vertical Drain System by the linear foot along the centerline of the underdrains, and from end to end of the underdrains, complete in place.

710.10 Basis of Payment

The Department will pay for accepted quantities of underdrains of the various kinds and sizes installed, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Aggregate Underdrains (With Pipe)	Linear Feet
Filter Cloth Underdrain	Linear Feet
Filter Cloth Underdrain (With Pipe)	Linear Feet
Lateral Underdrain	Linear Feet
Lateral Endwall	Each
Perforated Pipe with Vertical Drain System	Linear Feet

Such payment is full compensation for all excavation, backfill, connections, specials, and all other incidentals necessary to complete the work.

Payment for Filter Cloth Underdrain is full compensation for furnishing and installing the 4-inch perforated underdrain pipe and pipe elbow when an underdrain outlet is required.

Payment for Lateral Underdrain is full compensation for excavating the trench, furnishing and installing the outlet pipe and all materials, backfilling and compacting the trench, disposing of excess materials, returning the shoulder and slope to the previously existing normal condition, and for providing all tools, equipment, labor, and incidentals necessary to complete this item of work.

Payment for Lateral Endwalls is full compensation for excavation, concrete, backfill, compaction, disposal of excess material, and for all tools, equipment, labor, and incidentals necessary to complete this item of work.

Payment for 6-inch Perforated Pipe with Vertical Drain System is full compensation for the pipe and pipe elbows, the installation of the materials including the polyethylene sheeting, and for all tools, equipment, labor, and incidentals necessary to complete this item of work.

SECTION 711 – CONCRETE MEDIAN BARRIER

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DESCRIPTION

711.01 Description

This work consists of constructing cement concrete median barriers on a prepared subgrade.

MATERIALS

711.02 Materials

Provide materials as specified in:

Portland Cement	**901.01**
Fine Aggregate for Concrete	**903.01**
Coarse Aggregate for Class A Concrete:	
Size No. 467, 57 or 67	**903.03**
Joint Filler, Preformed Type	**905.01**
Steel Bar Reinforcement	**907.01**
Welded Steel Wire Fabric	**907.03**
Cement Concrete Curing Materials	**913.05**
Water	**921.01**
Air-Entraining Admixtures	**921.06**

Use Type I Portland cement unless otherwise specified or allowed by the Engineer.

For Portland cement concrete median barriers, use Class A concrete, meeting 604.

EQUIPMENT

711.03 Equipment

Provide the applicable equipment specified in 604.04.

CONSTRUCTION REQUIREMENTS

711.04 General

Construct concrete median barriers as shown on the Plans by fixed-form, slip-form, or precast methods.

Perform all necessary excavation and backfilling for the barriers, and satisfactorily dispose of all excess excavated material. Thoroughly compact the material adjacent to the median barrier base as directed by the Engineer.

Place slip-formed concrete with an approved slip-form placing machine designed to vibrate, consolidate, and finish the concrete in one pass of the machine so that a minimum of hand finishing will be necessary to provide a dense, homogeneous unit. Hold the sliding forms rigidly together to prevent spreading of forms, and ensure after passing there is no noticeable slumping of concrete. Hold the concrete at a uniform consistency.

Where the median is concrete, form transverse contraction joints in the base and barrier to match the adjacent concrete median. Where the median is asphalt, construct transverse contraction joints in the base and barrier at a uniform spacing of 15 to 20-foot intervals. Construct joints in the barrier directly over the joints in the base. Construct transverse contraction joints as shown on the Plans. Where concrete median barrier is installed on concrete pavement, the joints in the barrier and pavement shall coincide.

Construct expansion joints in accordance with Plan details. Form expansion joints about all bridge piers, drainage inlets, concrete gutters, and other

features projecting through, into, or against the barrier curb and base. Chamfer joints as specified in 604.

711.05 Finishing

Concrete median barriers shall present a smooth, uniform appearance in their final position, conforming to the horizontal and vertical lines shown on the Plans or as directed by the Engineer. Ensure the top surface and the top 6 inches of the barrier, when checked with a 12-foot straight-edge, do not vary more than 1/8 inch from the testing edge of the straight-edge when placed parallel to the center-line. Correct deviations in excess of this requirement.

Do not begin corrective work on extruded median barriers until the barrier surfaces have set sufficiently to withstand further damage that could be caused by making corrections. Give the exposed surface of the median barrier a rubbed finish (Class 2) or applied texture finish as specified in 604.21. However, should the median barrier abut a similar barrier on a bridge, give the roadway barrier the same finish as that required on the bridge median barrier.

711.06 Curing

Perform curing as specified in 604.23.

COMPENSATION

711.07 Method of Measurement

The Department will determine quantities of concrete median barrier, of the type specified, by measuring the length in linear feet, parallel to the centerline of the barrier, and including the joints but excluding all other openings in the barrier.

711.08 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Concrete Median Barrier (Description)	Linear Feet

Unless otherwise provided, such payment is full compensation for all required excavation, backfill, disposal of excess excavated material, reinforcement, joint materials, drilling and grouting, and all other incidentals necessary for the complete construction of concrete median barriers.

SECTION 712 – TEMPORARY TRAFFIC CONTROL

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DESCRIPTION

712.01 Description

This work consists of furnishing, erecting, and maintaining all construction warning signs, barricades, flexible drum channelizing units, temporary pavement markings, and other traffic control devices in accordance with the provisions of the current edition of the MUTCD, including all addenda, or as shown on the Plans or as directed by the Engineer for the purpose of safely directing traffic through construction zones. This work shall include installing additional devices as necessary in construction work zones.

MATERIALS

712.02 Materials

Provide traffic control and marking devices in accordance with the current edition of the MUTCD, except as herein modified.

Provide materials as specified in:

Signs:
Aluminum 916.02

Reflective Sheeting	916.06
Paint	916.09
Cold Rolled Carbon Steel -16 gauge	ASTM A1008
Non-metallic Drums and Barricades	QPL
Reflective Sheeting	916.06

A. Sign Sheeting Material

Sign sheeting material for all temporary construction signing shall be Type B or better, Fluorescent Orange color meeting the requirements of AASHTO M 268 and 916.06. For all interstate projects, provide new fluorescent orange sign sheeting material; for all other construction projects, provide new or previously used sign sheeting that is in good condition.

B. Temporary Pavement Marking Material

Unless otherwise specified, the material for pavement marking line shall be either temporary pavement marking tape, or reflectorized paint with raised reflective pavement markers placed as shown on the Plans.

Where Removable Pavement Markings are specified, provide materials listed on the Department's QPL. Before use, the manufacturer shall certify to the Department that the removable tape is identical to that listed on the Department's QPL. Failure of the removable tape to perform satisfactorily with regard to installation or removability is cause for rejection of the material.

C. Cones

Cones shall be a minimum of 28 inches high and weighted at the base.

D. Portable Barrier Rail

Portable barrier rail shall be in accordance with the Plans or as listed on the Department's QPL.

All portable barrier rail shall comply with NCHRP 350 or MASH. Provide certification from the supplier that the proposed rail replicates an NCHRP 350 or MASH approved rail documented in an acceptance letter from FHWA. Attach to the certification the acceptance letter stating that the proposed rail complies with NCHRP 350 or MASH. Submit all certification documents to the Engineer before delivery to

the Project. Do not use different shapes, lengths, or connections of rail in the same continuous run.

E. Portable Impact Attenuators

Portable impact attenuators shall be in accordance with the Plans and Specifications, comply with the requirements of NCHRP 350 or MASH for the appropriate test level, and be selected from the Department's QPL.

F. Sign Supports

Stationary sign supports shall be steel posts meeting **916**. Do not use wood for stationary or portable sign supports. Provide portable sign supports that have been pre-approved by the Engineer and comply with the requirements of the NCHRP 350 or MASH. In splicing supports, use 5/16-inch diameter galvanized ASTM A449 (SAE J429 Grade 5) or galvanized ASTM A325 bolts.

G. Vertical Panels

The substrate material for vertical panels shall be aluminum, meeting the requirements of **916.02**, or a high density copolymer polyethylene. The high density copolymer polyethylene shall be flexible and shatterproof for temperatures to -50 °F (ASTM D746). The reflective sheeting shall be AASHTO M 268 Type B or better, meeting the requirements for Fluorescent Orange material as specified in **916.06**. Attach the vertical panel (aluminum or copolymer) to a steel "U" post (weight 2.0 pounds per foot) meeting the requirements of **916.03**.

H. Flexible Drums, Flashing Arrow Boards, and Changeable Message Signs

Select Flexible Drums, Flashing Arrow Boards, and Changeable Message Signs from the Department's QPL.

Traffic control devices defined by the FHWA as Work Zone Category 1 and Category 2 devices weighing less than 100 pounds shall comply with NCHRP 350 or MASH. Select all Category 1 and Category 2 devices from the Department's QPL. Alternatively, the Contractor may submit a notarized letter, along with documentation from the FHWA, stating Category 1 devices and Category 2 devices weighing less than 100 pounds meet NCHRP 350 or MASH criteria.

Submit all certification documents to the Engineer before delivering these traffic control devices to the Project.

712.03 Reserved

CONSTRUCTION REQUIREMENTS

712.04 General

At the pre-construction conference, designate a responsible person who will be assigned to the Project to supervise traffic control.

Erect signs in a workmanlike manner such that all supports are plumb, sign panels are generally perpendicular to the travelway, and legends are horizontal so that they effectively convey the intended message. Do not display advanced warning signs more than 48 hours before physical construction begins. The Contractor may erect signs up to one week before needed, if the sign face is fully covered in a manner approved by the Engineer. Ensure that the sign sheeting is free of any damage that would reduce the reflectivity. Do not use overlay plates on signs. Mount signs on stationary or portable supports dependent on the type work being performed. Drive sign supports a minimum of 3.5 feet into soil or 1 foot into solid rock. Where soil and solid rock are both encountered, the depth of the sign support in the ground shall be:

$$d_1 + 3.5d_2 = 42,$$

where

d_1 = depth in inches of support in soil
d_2 = depth in inches of support in solid rock

The Contractor may splice stationary sign supports, provided the splice is a minimum of 18 inches. In addition, drive the stubs for the splice as required above and so as not to extend above 18 inches from ground level. Fasten the splice with four bolts, two placed at each end of the splice. In general, work being performed at spot locations and of short duration will necessitate the use of portable supports properly weighted for stability.

During periods of non-use, remove warning signs and other devices from the work area, and cover or otherwise position them so they do not convey their message to the traveling public and do not present a safety hazard to

drivers. If covered, maintain the covering material in a neat and workmanlike manner during its use. The method of covering the sign face shall not deface or damage the sheeting of the sign.

Use flashing or steady burning lights to light barricades and other devices that require lighting, as shown on the Plan details or as directed by the Engineer. Procure and bear the expense of a continuous power source.

A. Flaggers

Provide flaggers with proper attire and paddle when necessary to safely handle traffic through the construction zone. Ensure that flaggers are trained and certified in flagging operations by one of the following training programs:

1. American Traffic Safety Services Association (ATSSA)
2. National Safety Council (NSC)
3. Tennessee Transportation Assistance Program (TTAP)

The Department will accept flagger training programs developed and conducted by construction industry associations, consultant organizations, and contractors if they have an established, written program that meets all MUTCD requirements and Department Policy.

The Department will consider flaggers to be a general requirement of traffic control and will not make direct payment for such.

B. THP Troopers and Uniformed Law Enforcement Officers

When requested by the Engineer or the Contractor and approved by the Regional Safety Coordinator or Regional Operations Office, a Tennessee Highway Patrol (THP) Trooper may be provided to enforce motor vehicle laws and otherwise assist in securing the public safety. Submit requests for the THP at least 48 hours in advance of the requested time of service. If the THP is scheduled to work and the work is canceled, or the schedule is changed, notify the THP and the Engineer at least 2 hours before the scheduled start of work.

When a THP Trooper is not available, the Contractor may provide a Uniformed Police Officer if approved by the Engineer and the Regional Safety Coordinator or Regional Operations Office. The Uniformed Police Officer shall maintain a detailed written log of enforcement

activities and shall submit the log to the Engineer for verification each month.

All Uniformed Law Enforcement Officers working on Department projects shall have training from a Peace Officer Standards and Training (POST) certified police training academy in the State of Tennessee and an additional 4 hours of FHWA approved work zone training. Submit records of this training to the Engineer.

C. Flashing Arrow Board

Install Flashing Arrow Board(s), meeting all requirements of the MUTCD, at the locations shown on the Plans or as directed by the Engineer. Ensure that the Flashing Arrow Board(s) will perform as specified herein. Correct or immediately replace all Flashing Arrow Boards that exhibit any type of malfunction, including improper dimming.

The Flashing Arrow Board shall be capable of displaying the following configurations:

1. Right Arrow – ten lamps flashing in unison forming an arrow
2. Left Arrow – ten lamps flashing in unison forming an arrow
3. Double Arrow – five lamps in each arrow head and three lamps in a common shaft all flashing in unison
4. Four Point Caution – four outermost corner lamps flashing in unison

Use the Flashing Arrow Board(s) in the single arrow mode for lane closure only, and situate and align them so that the flashing arrow is clearly visible and legible. The single arrow mode display shall have ten lamps flashing in unison. Do not use the sequential arrow configuration, chevron arrow configuration, and horizontal bar configuration. The flash rate shall not be less than 25 flashes per minute or more than 40 flashes per minute. Minimum lamp "on-time" shall be 50% of the cycle.

Mount the Flashing Arrow Board(s) so as to provide a minimum of 7 feet between the bottom of the panel and the roadway.

D. Signs

The Contractor may use portable signs when the duration of the work is less than 3 days or as allowed by other conditions in the proposal. Ensure that all portable signs and sign mounting devices used in work are NCHRP 350 or MASH compliant. When not being used, remove portable signs from the clear zone. Do not turn signs sideways or backwards while the signs are in the clear zone. Mount portable interim signs a minimum of 1 foot above the level of the pavement edge and at the height recommended by the manufacturer's crashworthy testing requirements.

All regulatory sign blanks shall be rigid.

Make every effort to eliminate the use of interim signs as soon as the Work allows for the installation of permanent signs.

Maintain existing street name signs at street intersections.

Cover all signs or portions of a sign(s) that are not applicable to the Traffic Control Plan so as not to be visible to traffic, or remove such sign(s) from the roadway when not in use.

Do not remove existing signs and supports without the Engineer's prior approval. Store and protect all existing signs and supports that are to be removed if this material will be required later in the Work.

Furnish, install, reuse, and maintain interim guide, warning, or regulatory signs required to direct traffic in accordance with the MUTCD. Mount the bottom of all interim signs at least 7 feet above the level of the pavement edge when the signs are used for long-term stationary operations as defined by Section 6G.02 of the MUTCD.

Maintain existing guide and exit directional signs on the Project until conditions require a change in location or legend content. When change is required, the signs shall be in accordance with the Traffic Control Plan. When an existing guide and exit directional signs sign is in conflict with work to be performed, remove the conflicting sign and reset it in a new, non-conflicting location that has been approved by the Engineer.

When it is not possible to use existing signs, either in place or relocated, furnish, erect, maintain, modify, relocate, and remove new

interim guide and exit directional signs as shown on the Plans or as directed by the Engineer.

Complete the installation of new permanent guide and exit directional signs, and the permanent modification or resetting of existing guide and exit directional signs, when included in the Contract, as soon as practicable to minimize the use of interim guide and exit directional signs.

E. Worker Visibility and Safety

Ensure that all workers within the Project's right-of-way, who are exposed to either vehicular traffic or to construction equipment in the work area, wear high-visibility safety apparel. Consider high-visibility apparel to be personal protective clothing that meets performance Class 2 or Class 3 of the ANSI/ISEA 107 publication. Provide Class 3 apparel for night work.

F. Portable Barrier Rail

Place all portable barrier rail as far away from the travel lanes as possible while serving the intended purpose. Move or remove all portable barrier as directed by the Engineer. The Department will make no additional payment for removing barrier that is no longer required.

G. Lane Closures

Hold the length of a lane closure to the minimum length required to accomplish the Work. Locate advanced warning signs for the Project so as to not overlap with the advanced warning signs for lane shifts and lane closures.

Use drums in all transition tapers for lane closures on multi-lane roads.

H. Night Work Lighting

When the Contract requires night work, supply sufficient lighting and equipment as specified herein.

1. **Lighting Plan.** Submit the following information regarding the lighting plan to the Engineer:

a. Descriptions and sketches of the layout of lighting devices including spacing, luminary height, lateral placement, and anticipated illuminance provided.

b. Photometric and physical specifications of all lighting equipment.

c. Detailed description of all lighting to be used on construction equipment.

d. Methods to be employed to reduce glare.

e. Contractor's frequency and procedure for checking illumination levels.

2. Protective Equipment and Lighting. In addition to their standard protective equipment, equip construction personnel and equipment as follows:

a. Traffic Control Persons, all equipment operators, and all other workers shall:

(1) Wear high-visibility apparel that meets performance Class 2 or Class 3 of the ANSI/ISEA 107 publication. Class 3 apparel shall be required for night work.

(2) Have a minimum of 12 square inches of reflective material added to their hard hats that is visible from all sides.

b. Also equip Traffic Control Persons with:

(1) A flashlight complete with semi-transparent red cone, and

(2) Radios or cell phones so that they may communicate with each other.

c. All workers shall receive specific training on night work operations.

d. All vehicles in the work area must operate rotating or flashing incandescent amber lights visible in 360 degrees around the vehicle.

e. All work vehicles including trucks must have red and white reflective tape applied to all sides such that it defines the outline of the vehicle.

Provide the equipment specified in Table 712.04-1 with non-glare balloon style lights or equivalent. The lights will be required on each piece of equipment in operation.

Table 712.04-1: Night Work Lighting Requirements

Equipment Type	Illuminance Requirement
Paver, Milling Machine, Material Transfer Devices	One 4000-watt assembly or two 2000-watt assemblies
Grader, Roller, Rumble Strip Machine, Shoulder Machine	One 400-watt assembly
Paint truck	One 400-watt assembly or a non-glare 300-watt floodlight assembly
Guardrail driver, stationary operation	One 4000-watt assembly or two 2000-watt assemblies or equipment light plant
Trail Vehicle	One 4000-watt assembly or two 2000-watt assemblies

A trail vehicle will be required to follow the last piece of equipment in a mobile operation (i.e. finish roller, pavement marking, etc.) depicting the beginning of the working area. In addition, ensure that portable lighting of at least 400 watts is available for the density testing inspector. The Engineer will determine the illuminance requirement for other vehicles not listed in Table 712.04-1. The Contractor may substitute a 400-watt metal halide lamp or equal approved by the Engineer for a 2000 or 400-watt balloon light assembly.

Locate and direct all luminaries in such a way to minimize glare to both motorists and work vehicles. If glare is noted from any travel path, adjust the lighting to reduce the glare to a level acceptable to the Engineer.

Replace non-functioning lamps immediately. Check the luminary aiming daily. Regularly clean the luminaries.

I. Specification Compliance

The Engineer will notify the Contractor of failure to comply with this Specification or the Plans. The safe passage of pedestrians and traffic through and around the temporary traffic control zone, while minimizing confusion and disruption to traffic flow, shall have priority over all other Contractor activities. Continued failure of the Contractor to comply with the requirements of the Traffic Control Standard Specification or Special Provisions will result in non-refundable deductions of monies from the Contract for non-performance of Work as long as the deficiency remains.

Failure of the Contractor to comply with this Specification or take immediate correction actions required within 48 hours of written notice shall be reason for the Engineer to suspend all other work on the Project, except erosion prevention and sediment control and traffic control, to apply non-refundable deductions of monies from the Contract at a rate of $2,500 per calendar day per notice, and to withhold payment of monies due to the Contractor for any work on the Project until traffic control deficiencies are corrected. These other actions shall be in addition to the deductions for non-performance of traffic control.

712.05 Pavement Marking Removal

Remove conflicting pavement markings, in a manner acceptable to the Engineer, to prevent confusion to vehicle operators.

Remove final surface pavement markings by sand blasting, water blasting, or acceptable grinding methods that will cause the least possible damage to the pavement.

Remove intermediate surface pavement markings by sand blasting or water blasting, or other approved methods that will cause the least possible damage to the pavement. The following methods are acceptable for removing intermediate surface pavement markings: sand blasting using air or water, high pressure water, steam or superheated water, or mechanical devices such as grinders, sanders, scrapers, scarifiers, and wire brushes.

At no cost to the Department, repair damage to the pavement or surface resulting from pavement marking removal using methods and materials

acceptable to the Engineer. The removal shall not result in what appears to be a line that conflicts with the current markings.

Accomplish traffic shifts on the final surface using interim traffic marking tape unless otherwise shown on the Plans.

Do not remove an existing pavement marking by painting over with black paint or asphalt.

When the method of removal causes sand or other material to accumulate on the pavement, remove the residue as the work progresses.

712.06 Temporary Centerline and Lane Marking

Unless otherwise specified, install temporary pavement marking as follows:

1. Provide 4-inch wide pavement marking line as shown on the Plans for projects that will have traffic maintained overnight. For temporary pavement line markings on intermediate layers of pavement, use reflective tape, reflectorized paint, and raised pavement markers, or a combination thereof as shown on the Plans or as required by the Engineer, and install to permanent standards before dark hours. Short, unmarked sections will not be allowed. The Department will measure and pay for these markings as Painted Pavement Marking (Line) in accordance with **716.08** and **716.09**. Preserve established no-passing zones, if any, on the existing pavement; if no-passing zones have not previously been established, establish them before beginning the work. Mark two-lane, two-way highways with 10-foot long center lines applied on 40-foot centers and appropriate no-passing barrier lines.

2. Where required on the completed permanent surface, for 10-foot lane lines, no-passing barrier line, and edge line, use reflectorized paint applied as specified in **716**.

3. Maintain pavement markings at no additional cost to the Department until they are covered by the subsequent paving course or the Project is accepted.

4. It will not be necessary to remove pavement markings except for markings that convey conflicting or incorrect information to the traveling public.

712.07 Maintenance

Assume full responsibility for the continuous and expeditious maintenance of all signs, barricades, temporary impact attenuators, and all other traffic control devices to meet the "acceptable" category as described in *Quality Guidelines for Temporary Traffic Control Devices and Features* published by ATSSA. Such maintenance will be considered a part of the original installation cost. Failure to maintain all traffic control devices so as to provide continuous safety to the public will be cause for suspension of construction operations until proper traffic control is re-established.

712.08 Adjustment to Plans

Maintain traffic through the Project in accordance with the traffic control plan and the MUTCD. To request a change to the traffic control plan, submit a plan revision request in writing to the Engineer for approval, with the requested change marked in red on the traffic control plans sheets. The Engineer may adjust the traffic control plan as deemed necessary to ensure the safety of the workmen and traveling public.

COMPENSATION

712.09 Method of Measurement

The Department will measure the following for payment:

1. Signs, including Vertical Panels, erected on suitable supports by the actual area in square feet installed, with no deductions made for corner radii.

2. Flexible Drums for channelizing traffic by the unit, per each, as determined by counting the maximum number of drums on a jobsite and in use at any one time. This shall be designated by making a notation such as "On October 29, 2013, there were 242 Flexible Drums in use. Pay quantity is 242 Each." This will not apply to phase construction projects. On phase construction projects, each phase is treated as a separate project to arrive at a final pay quantity. The highest number used on Phase I, plus the highest number used on subsequent phases, will constitute the final pay quantity.

3. Barricades by the linear foot for the type designated.

4. Delineators and Temporary Flexible Tubular Delineators by the unit, per each.

5. Warning Lights and Flashing Arrow Boards by the unit, per each for the type designated.

6. Portable Barrier Rail by the linear foot. Separate measurement will be made for the initial installation of portable barrier rail at each site that the rail is used on the Project as shown on the Plans or approved by the Engineer. No separate measurement will be made for removing and resetting portable barrier rail on new alignment at the same site to provide for changes in traffic control required by the different phases of construction. The following conditions apply to measurements of portable barrier rail:

    a. The sites on one directional roadway of a divided highway will be considered independently of the sites on the other directional roadway.

    b. Each bridge for which portable barrier rail is shown on the Plans or approved by the Engineer will be a separate site.

    c. Additional relocations of barrier rail due to safety of work zone or traffic, as established in the traffic control plans or as directed by the Engineer laterally up to 10 feet, will be paid at 10% of the interconnected portable barrier bid amount unless a separate item is in the proposal.

7. Portable Impact Attenuators based on the initial installation of each portable impact attenuator. No additional payment will be made for removal, moving, and reinstalling impact attenuators at other locations on the Project as directed by the Engineer. Payment will be based on the maximum number of portable impact attenuators in place at one time.

8. Temporary pavement marking line as described for Painted Pavement Marking Line in **716.07** regardless of whether the lines are painted, taped markings, or raised pavement markers, or a combination of the above as shown on the Plans or as required by the Engineer, except that Removable Pavement Marking (Line) will be measured by the linear foot of installed line.

Unless otherwise specified, the Department will not separately measure or pay for traffic cones, removal of pavement marking, and flaggers, as these items will be considered incidental to the lump sum item Traffic Control.

The Department will pay for THPs, but the Contractor is responsible for notifying the THP and the Engineer when work has been canceled within 2 hours of the scheduled start of work. If the THP is not notified of work cancellation and the THP elects to monitor/patrol the project for a maximum of 2 hours, the Department will deduct from the monies owed the Contractor an amount equaling the THP pay rate for 2 hours of work.

The Department will pay for Uniformed Police Officers provided by the Contractor at the invoice price of the work plus 5%, not to exceed $50 per hour for the hours present on the Project. No compensation will be made for drive time.

712.10 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Traffic Control	Lump Sum
Portable Barrier Rail	Linear Feet
Portable Impact Attenuator	Each
Signs	Square Feet
Vertical Panels	Square Feet
Flexible Drums	Each
Temporary Barricades (Type)	Linear Feet
Removable Pavement Marking (Description)	Linear Feet

The lump sum payment for Traffic Control is full compensation for providing Temporary Workzone Lighting and all equipment, labor, and materials, and for furnishing flaggers and traffic cones, and for removing conflicting and incorrect pavement markings, as required, until Project completion.

Payment for Portable Barrier Rail is full compensation for all materials, installation, maintenance, and all incidentals necessary to complete the work.

Payment for Portable Energy Absorbing Terminals will be made at the contract price per Portable Energy Absorbing terminal, complete in place,

with total payment based on the maximum number of portable energy absorbing terminals in place at one time as specified in **712.09**.

Payment for Signs and Vertical Panels is full compensation for providing sign panels with proper sheeting and legend, erecting on proper supports, furnishing all mounting hardware, covering when not in use, relocating, handling, and maintaining until Project completion.

Payment for Barricades is full compensation for materials, equipment, relocating, handling, maintaining, and all incidentals of the work.

Unless otherwise designated, all signs, barricades, and other traffic control devices covered by this section shall become the property of the Contractor at the completion of the Project. The salvage value for these items shall be reflected in the contract unit price bid.

The Department will pay for 10-foot lane line/center line and solid barrier line as Painted Pavement Marking (Line) in accordance with **716.08**.

Payment for Removable Pavement Marking Line, 8-inch Barrier Line, Channelization Striping or Stop Line, is full compensation for the installation, maintenance, and removal of the marking line when it is no longer required.

Payment for Uniformed Police Officers is full compensation for providing the Officer, official law enforcement vehicle, all necessary equipment, and administrative costs associated therewith.

SECTION 713 – HIGHWAY SIGNING

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DESCRIPTION

713.01 Description

This work consists of constructing foundations and supports, fabricating, furnishing, assembling, and erecting traffic signs on the supports, including delineators when specified, for a section of highway, its interchanges, frontage roads, and roads or streets affording immediate access to the highway.

Construct and erect highway signs and devices in accordance with these Specifications and the MUTCD, latest edition.

The Plans will show the extent and general arrangement of the signs. Refer to the Plans for general guidance. If departures from the Plans and Specifications are deemed necessary by the Contractor, submit the reasons for and details of such departures to the Engineer for approval. Do not make any departure without the Engineer's prior written approval. For departures from the Plans, submit for the Engineer's approval eight copies of drawings showing the complete design of the proposed departure and all other information necessary to complete the sign assembly.

MATERIALS

713.02 Materials

Provide materials as specified in:

Portland Cement Concrete, Class A..... **604**
Highway Signing Material..... **916**

713.03 Reserved

CONSTRUCTION REQUIREMENTS

713.04 Construction Methods and Requirements

Before beginning any excavation or driving any sign posts, determine the location of all underground electrical, drainage, and utility lines in the vicinity, and perform work so as to avoid damaging these facilities.

All signs are numbered or otherwise identified. Locate signs as shown on the Plans. Obtain the Engineer's approval for all changes in locations before erection.

Locate delineators as shown on the Plans and in accordance with the MUTCD**.**

Place the top of all sign footings level with the ground line. Remove the existing footings of signs to be eliminated to 6 inches below ground line.

The Engineer, or Contractor when required, will stake the location of all sign supports and delineators and mark the location of each sign with the number of the sign. After the sign locations have been staked, but before ordering any material for the supports, allow for a field inspection and approval by the Engineer. Construct the signs at the approved locations.

A. Flexible Delineator Posts

Drive the flexible delineator posts or anchors into the ground with equipment that does not damage the posts, anchors, or the reflective sheeting. Drill or form pilot holes where necessary to obtain the embedment shown on the Plans.

B. Post Supports for Ground Mounted Signs

Furnish and erect post supports consisting of one or more posts of the type shown on the Plans.

Drive all posts into the ground, or bolt to a stub in the concrete foundation. Plumb, align, and orient posts as shown on the Plans. To drive posts, use a method that will not damage or deface the top of the post.

For sign posts that are to be bolted to or stubbed in a concrete foundation, excavate as nearly to neat lines as possible and generally pour all parts of the sign post foundation against the soil or rock face. Use forming below ground level in sandy soils or when directed by the Engineer. Forming will be required for all concrete work above the finished ground level and the top 12 inches of all concrete work. Provide necessary braces to keep anchor bolts and stubs in proper position. For foundations, use Class A concrete, meeting the requirements of **604.03**. Perform forming and concrete work as specified in **604**. Remove and dispose of all surplus excavated material.

Repair all cracked, chipped, or scratched galvanized steel members by "touching-up" with an approved zinc powder, wire, stick, or spray manufactured especially for this purpose. The zinc powder, wire, or stick shall become completely liquid at a temperature no greater than 475 °F. Thoroughly clean the area to be regalvanized, including removing slag on welds, and repair according to the recommendations of the manufacturer of the material being used.

C. Foundations for Sign Supports

Furnish all materials and labor, and perform all necessary construction to complete the foundations upon which the sign supports will be erected.

1. **Excavation and Backfill.** Excavate and backfill as specified in **204**.

2. **Disposing of Surplus or Unsuitable Material.** Dispose of surplus or unsuitable material as specified in **203.07**.

3. **Forms.** Construct forms as specified in **604.05**.

4. **Steel Reinforcement.** Provide steel reinforcement as specified in **604.08**.

5. **Electrical Conduit.** Install electrical conduit, when specified, in the foundations as shown on the Plans.

6. **Concrete.** Use Class A concrete meeting **604.03**.

7. **Placing Concrete.** Place concrete as specified in **604.16**.

8. **Setting Anchor Bolts and Stubs.** Set anchor bolts and stubs for sign supports to proper locations and elevations with templates, and carefully check them after constructing the sign foundation and before the concrete has set.

9. **Surface Finish.** Perform finishing as specified in **604.21**.

10. **Curing.** Cure concrete as specified in **604.23**.

D. Column Supports for Cantilever Structures

Fabricate and erect supports and horizontal arms constructed of galvanized steel. The supports shall consist of one or more vertical poles, one or more horizontal arms, and all necessary fastenings for assembling the units and anchoring the supports to a foundation.

Use leveling nuts to plumb supports. Erect cantilever supports so that the arms are horizontal.

Assemble all high strength bolt connections as specified in **602.17**.

Perform all welding as specified in **602.19**.

The Engineer will reject supports on which galvanizing has been damaged in transportation, handling, and erection. With the Engineer's approval, the Contractor may replace such damaged supports in the field as specified in **713.04.B**. The repaired area shall be similar in appearance and in coating thickness to the original coating. The Engineer will reject supports that are not coated satisfactorily.

E. Supports for Overhead Sign Structures

Fabricate and erect truss sign supports constructed of aluminum or galvanized steel.

Erect the structures with the specified camber and so as to prevent excessive stresses, damage, or defacement.

Provide brackets for mounting signs (including future signs) of the type to be supported by the structure. They shall be adjustable to allow mounting of the sign faces at any angle between a truly vertical position and 3 degrees from vertical. Obtain this angle by tilting the top of the sign toward traffic. All brackets shall be of a length equal to the heights of the signs being supported.

Before erecting aluminum end supports, protect the bottom of each base plate with an approved material that will adequately prevent any harmful reaction between the plate and the concrete.

Use leveling nuts to plumb the end supports. Do not fill the space between the base plate and the foundation with grout.

Tighten all nuts on aluminum trusses, except those used on the flanges, only until they are snug. This includes the nuts on the anchor bolts. Use a thread lubricant with each aluminum nut.

Tighten all nuts on galvanized steel trusses, with the exception of high strength bolt connections, only to a snug condition. Assemble all high strength bolt connections as specified in 602.17.

Repair galvanizing on steel trusses as specified in **713.04.B**.

Field welding will not be permitted.

F. Signs

Furnish, fabricate, and erect signs on their supports.

When alternates are allowed, all legends, borders, and accessories for an entire project shall conform to the requirements of one and only one of the alternates.

Mechanically apply the reflective sheeting to the properly prepared aluminum with the equipment and in the manner prescribed by the sheeting manufacturer.

All completed signs shall be free from defects in materials and workmanship and shall effectively present the specified message under conditions of both day and night viewing. Reflectorized sign surfaces shall exhibit uniform color and brightness over the entire background surface and shall not appear mottled, streaked, or stained when viewed either in ordinary daylight or in the incident beam of an automobile headlamp.

The reflectorized legend optical performance shall uniformly reflect incident light from motor vehicle headlamps back to the eyes of the operator at entrance angles up to 30 degrees without gaps or irregularities.

Position signs on, and fasten them to, the support as shown on the Plans or as directed by the Engineer. All signs, once erected, shall be clean and free of substances that would hide or otherwise obscure any portion of the sign face. Attach flat sheet signs to the posts with tamper resistant fasteners.

After the sheeting is thoroughly attached to the sign face, attach demountable letters, digits, borders, shields, and alphabet accessories flush against sign faces, with corrosive resistant fasteners as recommended by the manufacturer. Use a sufficient number of fasteners to securely fasten demountable legends and borders to sign panels.

Provide demountable borders of the width shown on the Plans. Place demountable borders as shown on the Plans. Spacing of all legends shall meet the FHWA Standard Alphabets for Highway Signs. Any improper size or spacing of legends and borders shall be cause for rejection of the entire sign.

713.05 Final Cleanup

Before final inspection, clean exposed sign and support surfaces, and level and repair the site as directed by the Engineer to ensure the effectiveness and neat appearance of the work. Perform final cleanup as specified in **104.10**.

COMPENSATION

713.06 Method of Measurement

The Department will measure:

1. Class A Concrete and Steel Bar Reinforcement for embedment of sign supports, and for foundations for sign supports and overhead sign structures, in accordance with 604.30.

2. Mile Marker and Steel Posts by the unit, per each, complete in place.

3. Flexible delineator posts with reflective sheeting, anchors, and all material necessary for erection of this item payment by the unit, per each, in place.

4. Aluminum or Steel Hollow Square Posts for sign supports, Aluminum or Steel I-Beams and WF-Beams for sign supports, Structural Steel Hollow Square Posts (Break-Away) for sign supports, and Structural Steel I-Beams and WF-Beams (Break Away) for sign supports by the pound based on the nominal weight per foot listed on the sign schedule, for the various sizes and weights used, complete in place.

5. Aluminum or Steel Overhead Sign Structures and Steel Cantilever Sign Structures by the unit, per each, complete in place, including the footings and all incidentals necessary to construct these items.

6. "U" Section Steel Posts by the pound, based on the nominal weight per foot listed on the sign schedule, for the various sizes and weights used, complete in place.

7. Flat Sheet Signs by the square foot for each thickness, complete in place.

8. Extruded Aluminum Panel Signs for payment by the square foot complete in place, except that the measurement will be made only for the actual dimensions of the extruded panels. No payment will be allowed for any space between panels.

The Department will consider conduit, excavation, and backfilling to be incidental to the associated items.

713.07 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Class A Concrete (Foundation for Sign Supports)	Cubic Yard
Steel Bar Reinforcement (Foundation for Sign Supports)	Pound
Mile Marker & Steel Post	Each
Flexible Delineator (Description)	Each
(Description) Sign Supports	Pound
Steel Overhead Sign Structure (Span ___)	Each
Steel Cantilever Sign Structure (Sign No.)	Each
"U" Section Steel Posts	Pound
Flat Sheet Aluminum Sign (___" thick)	Square Feet
Extruded Aluminum Panel Sign	Square Feet

Such payment is full compensation for furnishing all materials, equipment, tools, labor, and incidentals necessary to complete the work.

SECTION 714 – ROADWAY AND STRUCTURE LIGHTING

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DESCRIPTION

714.01 Description

This work consists of furnishing and installing roadway and structure lighting systems complete or to the extent shown on the Plans.

MATERIALS

714.02 Materials

Provide materials as specified in **917** and as follows:

Portland Cement Concrete, Class A	**604**
Crushed Stone Grading D	**903.05**
Steel Bar Reinforcement for Concrete Structures	**907.01**
Welded Steel Wire Fabric	**907.03**
Gray Iron Castings	**908.07**
Inorganic Zinc Paint	**910.03**
Cement Concrete Curing Materials	**913**
Conduit	**917.05** or **917.07**

Within 30 days after the issuance of the work order, submit to the Engineer, four collated sets of the manufacturer's descriptive literature and technical data, fully describing the types of lighting equipment proposed for use. In the descriptive literature, identify the manufacturer and model, and include sufficient information for the Engineer to determine if the equipment or material meets the requirements of the Plans and these Specifications. Include with these sets of submittal data a list of the materials submitted along with descriptive material for, but not limited to, the following items when applicable:

1. Complete photometric data of luminaires as published by the manufacturer with independent testing laboratory results.

2. Computer printouts showing illumination levels throughout each interchange area where high mast luminaires are to be installed.

3. General details of light standards, breakaway bases, and bracket arms. For light standards taller than 30 feet, submit one set of design calculations and six prints of "Design" or "Shop" drawings to the Division of Structures for approval purposes. The Department will review these drawings at the earliest possible date, and will return two prints marked "Approved for Fabrication," or "Returned for Revisions as Noted." Respond by taking appropriate action to ensure the earliest possible correction of these items so as not to delay the installation.

4. Highmast tower details with a set of design calculations for each height including access hole, base, anchorage, head frame, and

lowering device. Include specification references for materials and location, type, size, and extent of welds. In addition to the set of design calculations, submit six prints of "Design" or "Shop" drawings for each highmast tower height to the Division of Structures for approval purposes, in a manner similar to that specified in Item 3 above for light standards taller than 30 feet.

5. Dimension sheets and performance data on all related equipment.

The Engineer will retain one copy and forward one copy each to the Regional Materials and Test Division, the local entity (city or county engineer), and the Design Division for their review.

Also include with the submittal sets detailed scale drawings of all non-standard or special equipment and of all proposed deviations from the Plans. Deviations from the Plans or Specifications require approval from the Design Division. Include a letter requesting deviations or alternate materials in the submittal for Design Division approval. Upon request, submit for approval sample articles of materials proposed for use. The Department will not be liable for any materials purchased, labor performed, or delay to the Work prior to such approval.

In addition to the above, include with each submittal a notarized letter certifying that all lighting system materials listed in the submittal conform to the Plans and Specifications. Also submit to the Engineer a statement from the Maintaining Agency that the system is acceptable to the Agency.

714.03 Codes

Furnish material and perform all work in strict accordance with the latest revision of the National Electrical Code, the National Electrical Safety Code, the Illuminating Engineering Society (IES) publications, ANSI standards, and the codes, regulations, and rules prevailing in the area in which the Work is being performed, as applicable.

714.04 Reserved

CONSTRUCTION REQUIREMENTS

714.05 Conduit

Install conduit of the type and size specified at the locations shown on the Plans, or as directed by the Engineer. Install pull or drag wires of the type and size specified in conduit at the locations shown on the Plans.

A. Underground Conduit

1. **General.** Underground conduit shall consist of encased or direct burial conduit. Install conduit in a trench excavated to the dimensions and lines specified.

   Before beginning any excavation, determine the location of all electrical, drainage, and utility lines in the vicinity, and perform work so as to avoid damaging these facilities. Ensure that the conduit will be located so as to avoid conflict with proposed guardrail, sign posts, and other features.

   Build conduit runs in straight lines where possible. Where sweeps are necessary, use standard long sweep conduit bends when feasible, and meet the minimum radius required by the National Electric Code. Install pull boxes at intervals so that the tensile strength of the conductors will not be exceeded.

   Obstructions encountered when excavating trenches for underground conduit may require minor changes, such as in locations of conduit runs and pull boxes. Obtain the Engineer's approval before making such changes. Where possible, provide a minimum of 12 inches between the finished lines of conduit runs and utility facilities, such as gas lines, water mains, and other underground facilities not associated with the electrical system. Where the conduit run is adjacent to concrete walls, piers, footings, and similar structures, maintain a minimum of 4 inches of undisturbed earth or firmly compacted soil between the conduit and the adjacent concrete or, when the conduit is encased, between the encasement and the adjacent concrete.

Unless shown on the Plans, do not excavate trenches in existing pavement or surfaced shoulders to install conduit. If it is necessary to place a conduit under an existing pavement, install the conduit by jacking or other approved means with galvanized rigid steel conduit or schedule 80 PVC conduit.

Keep jacking and drilling pits at least 10 feet from the edge of the paved shoulder or sidewalk unless otherwise directed by the Engineer. When the Plans specifically allow excavation of a trench through an existing pavement or surfaced shoulder, restore the pavement and/or surface and base to their original condition. Do not leave boring pits open for extended periods of time.

Unless otherwise specified, cut trenches for conduit on a slight grade for drainage, and make the walls of the trench essentially vertical. Tamp the bottom of the trench as necessary to produce a firm foundation for the conduit.

Excavate trenches for rigid metallic conduit, with or without encasement, to a minimum depth of 18 inches, plus conduit diameter, measured from the finished subgrade.

Sheet and brace the trenches as required, and adequately support all pipe and other structures exposed in trenches as necessary to prevent damage.

Ream metallic conduit after threads are cut. Ream other conduit as necessary. Cut all ends square and to butt solidly in the joints to form a smooth raceway for cables.

Ensure that conduit joints form a water-tight seal. Coat metallic conduit threads with pipe compound and then securely connect. Make conduit joints with the materials and in the manner recommended by the conduit manufacturer and as approved by the Engineer.

Install conduit bushings in conduit where necessary and required for protection of the conductors. When the conduit is installed for future use, ensure that the ends of metallic conduit runs are properly threaded and capped, and that the ends of non-metallic conduit runs are satisfactorily plugged or capped to prevent water or other foreign matter from entering the conduit system.

a. Encased Conduit. Place encased conduit under roadway and paved shoulders unless trenching is required for installation at the locations shown on the Plans. Unless otherwise specified, construct encasement as follows:

(1) Construct the encasement of Class A concrete meeting the requirements of **604**, except that the coarse aggregate shall be size 67 or 78.

(2) Extend the encasement of conduit under roadway pavements or surfaces to the outer edges of the surfaced or paved shoulders, or 1 foot beyond the outer edge of the sidewalk, or 1 foot beyond the outer edge of the curb when no shoulder or sidewalk is indicated.

(3) Extend the conduit at least 6 inches beyond the encasement.

(4) Encase the pipe with a minimum of 3 inches of concrete.

(5) Plug the ends of the conduit temporarily to prevent the entrance of concrete or other foreign material.

(6) Do not encase any conduit with concrete until inspected and approved by the Engineer.

(7) Cure concrete encasement as specified in **604.23**, except that the curing period may be reduced to 24 hours if backfilling is to proceed at the time specified in **714.05.A.2**.

b. Direct Burial Conduit. When rock is encountered in the bottom of the trench, install the conduit on a bed of well compacted fine grain soil at least 4 inches thick.

2. Backfilling Conduit. Do not backfill encased conduit until the concrete encasement has cured a minimum of 24 hours. After the Engineer has inspected and approved the installation of direct burial conduit, promptly backfill to the required grade with approved material in layers not exceeding 6 inches in loose depth, and compact each layer as directed by the Engineer.

B. Conduit on Structures

Install conduits, conduit fittings, hangers, expansion fittings, and accessories on as shown on the Plans and, unless otherwise specified, in accordance with the following:

1. Run conduit parallel to beams, trusses, supports, pier caps, and similar features in the most direct manner.

2. Install horizontal runs on a slight grade, without forming low spots, to ensure proper drainage.

3. Run conduits with smooth, easy bends.

4. Hold conduits in boxes with locknuts and provide bushings for protection of the conductors.

C. Testing Conduit

After completing the installation of conduit, test it with a metallic mandrel in the presence of the Engineer. Use a mandrel having a diameter 1/4 inch smaller than the conduit, and a length of 2 inches. Repair, to the Engineer's satisfaction, all conduits that will not allow passage of the mandrel. If repairs cannot be accomplished, remove and replace the conduit at no additional cost to the Department.

After the mandrel test, scour all conduits with a stiff wire brush having a slightly larger diameter than the conduit.

Test conduits that have been installed under a previous contract with a mandrel and clean as described above before installing the cables.

714.06 Pull Boxes

Construct pull boxes in accordance with the design, dimensions, and at the locations shown on the Plans. Construct concrete pull boxes of Class A concrete meeting the requirements of 604. Place non-metallic pull boxes only in non-traffic bearing locations and not in paved areas.

Provide a cast iron frame and cover or reinforced concrete cover, as shown on the Plans, with each pull box.

Plug unused conduit entrance holes and openings for conduit to be extended by others with suitable plugs of plastic, bituminous fiber, or other approved material to prevent the entrance of foreign matter.

714.07 Underground Cable for Lighting Circuits

Underground cable for lighting circuits shall consist of direct burial cable, preassembled cable in duct, or cable in conduit, as shown on the Plans.

If it is necessary to install a cable under an existing pavement or surfaced shoulder, install conduit, when specified, in accordance with the applicable provisions of **714.05**, and place the cable within the conduit.

Construct walls of trenches for cables to be essentially vertical. Unless otherwise specified, install underground cable as follows:

1. Excavate trenches for direct burial cable to a minimum depth of 24 inches plus the cable diameter as measured from finished subgrade.

2. In general, locate the trenches to avoid conflict with proposed guardrail, sign posts, and other features.

3. Protect direct burial cable, and preassembled cable in duct, in trenches by cushioning with sand or earth that passes a 1/4-inch screen. Place the cable, or preassembled cable in duct, and sand or earth in the trench so that a minimum 3-inch thickness of the cushion material will completely surround each cable.

A. Direct Burial Cable

Do not unreel cables and pull into the trench from one end. Unreel the cables, lay them alongside the trench, and then lay in the trench. Allow the cables to "snake" slightly in the trench to provide adequate slack for settling of earth. Ensure that there are no crossovers of cable in the trench. Where cable is brought up into the base of the lighting standard, leave sufficient slack for making the connections inside the standard.

B. Preassembled Cable in Duct

When installing in the trench, do not pull preassembled cable in duct taut, but allow it to "snake" in the ditch to provide not less than 18 inches slack per 100 feet of trench. The minimum bending radius

on the cable duct shall be 18 inches. Where the duct is brought into the base of the lighting standard or into a pull box, leave sufficient length for trimming the duct to expose enough cable to allow for the connections to be made inside the standard or pull box.

C. Cable in Conduit

Carefully pull cables in conduits into place using approved methods so that the cable will be installed without electrical or mechanical damage. Pull all cables within a single conduit at the same time. If necessary to ease the pulling, the Contractor may use a lubricant of the type recommended by the cable manufacturer. When cables are pulled through hand holes in pole shafts, place a pad of firm rubber or other suitable material between the cable and the edges of the opening to prevent cable damage.

After the cable has been installed in the conduit, seal the ends of buried conduit with approved pliable and non-hardening material to prevent the entrance of dirt, moisture, or other foreign material.

D. Splices

Splice conductors as shown on the Plans. Only make splices at accessible points, such as handholes and pull boxes, unless otherwise shown on the Plans. After making a conductor splice, insulate it with heat-shrinkable tubing, supplied by the manufacturer, with an adhesive coating on the inner wall.

E. Ground Wire

Install ground conductors of the type and size shown on the Plans, and to be continuous in trenches with direct burial cable, and continuous inside preassembled cable in duct, and in conduit. Connect the ground conductors to the ground rod at all control points, to the ground lug in pole foundations, and to all metallic conduit runs using a grounding bushing, except that the connections to conduit in pole foundations may be omitted. Make all connections as shown on the Plans.

F. Backfilling Underground Cable

Backfill cable as specified in **714.05**.

G. Cable Identification

To assist in the identification of circuits at the pull boxes, mark the phase conductors with colored rubber-based, or equivalent, paint. When final connections are made, provide permanent tape wire markers to identify the branch circuit conductors (X1A, X1B, etc.), neutral (X1N, etc.), and the ground(g).

714.08 Light Standards

Install light standards of the designated design, kind, size, and class in accordance with and at the locations shown on the Plans. Ensure that the installed standards, complete with the bracket arm(s) and luminaire(s) as specified, provide the mounting height shown on the Plans. Determine the pole height as required by bracket arm upsweep, slope conditions, and similar characteristics.

A. Foundations for Light Standards

Consider transformer bases to be an integral part of the lighting standard unless otherwise specified.

1. Bolt-Down Base Pole Foundations

a. Concrete Foundations. Excavate a hole of the size and depth shown on the Plans. Remove and dispose of all excavated material as directed by the Engineer. Place anchor bolts of the type and size specified according to the pole manufacturer's recommendations, and securely hold to ensure proper position in the completed foundation. Ensure that no realignment of anchor bolts will occur after the foundation is poured. Accurately place reinforcing steel and securely hold to avoid displacement.

Accurately place conduits in foundations, orient them in the proper direction to accommodate service cables, and securely hold to avoid displacement.

Place Class A concrete in the excavated area against undisturbed earth to an elevation 4 inches below the finished ground line, and in an approved form from 4 inches below said ground line to the finished top of foundation elevation, as specified. Construct the foundation with a continuous

concrete pour. Chamfer the edges of the top and formed portion of the foundation. Apply a Class 2 finish, as specified in **604.21.B**, to the portion of the foundation above grade and within 4 inches of grade.

b. Metal Foundations. Install metal foundations where shown on the Plans and, if desired, at locations where installation is possible without predrilling the hole.

2. Prestressed Concrete Butt Base Pole Foundations. The Contractor may excavate prestressed concrete butt base lighting standard foundations using manual or mechanical methods. Dig or drill the holes to the depth and the diameter shown on the Plans. Place and compact in the bottom of the hole 6 inches of crushed stone, meeting the requirements of **903.05**, Grading D.

3. Wood Poles. Excavate for wood poles as specified for prestressed concrete butt base pole foundations in **714.08.A.2**. Dig or drill the holes to the depth shown on the Plans and in such diameter to allow satisfactory use of mechanical tamping equipment.

B. Light Standard Installation

Handle the standards or poles as recommended by the manufacturer and approved by the Engineer. Accomplish erection without marring the finish or otherwise damaging the standard. Ground the light standards as shown on the Plans. When installing lighting on a bridge, review the proposed bridge plans or the completed structure before ordering the standards.

1. Bolt-Down Base Poles. Set standards with bolt-down bases on foundations constructed as specified in **714.08.A.1**. Use metal shims supplied with the poles to plumb the pole, if the twin bracket arm type is used; and, unless otherwise specified, to rake or lean the pole backward 4 inches, if the single bracket arm type is used.

2. Prestressed Concrete Butt Base Poles. Place prestressed concrete butt base lighting standards in the hole and on the layer of crushed stone prepared as specified in **714.08.A.2**. Position the pole in the center of the hole at grade and hold in place. Rake the lighting standards with single bracket arms as specified for poles with bolt-down bases in **714.08.B.1**. Set lighting standards with two bracket arms plumb. Fill the space surrounding the pole butt-

base with crushed stone, applied in 6-inch layers. The crushed stone shall meet the same requirements specified for the stone foundation in **714.08.A.2**. Moisten the stone backfill material as necessary, and thoroughly compact each layer with mechanical tamping equipment. Continue the backfill with crushed stone to the depth of the bottom edge of the cable entrance in the butt-base. After completing the installation of the electrical cable, continue placing the crushed stone backfill in 6-inch layers, and compact to a depth of 1 foot below grade. Backfill the remaining 12 inches with soil in two equal layers, and thoroughly compact each layer.

3. **Wood Poles.** Place wood poles in holes excavated as specified in **714.08.A.2**. Set the pole in the center of the hole, with any vertical curvature of the pole located in the plane of the lines, and rake in a direction opposite that of the unbalanced stress where a guy or underbrace is specified. Backfill the hole with approved material applied in 6-inch layers, and thoroughly compact each layer with mechanical tamping equipment. Install cross arms and guying components, when specified, as shown on the Plans.

C. Highmast Tower Installation

Install standards with lowering devices on foundations constructed as shown on the Plans. Ensure that the standards are plumb. Assemble the shaft in the Engineer's presence. Do not perform any field welding between sections of the shaft. Erect the tower according to the manufacturer's recommended procedures and under the manufacturer's supervision. Make adjustments to align all parts and ensure operation. Arrange for the manufacturer or its representative to instruct the local utility in the proper operation of the lowering device.

714.09 Bracket Arms

Install, on the lighting standards, bracket arms of the specified type, design, kind, dimensions, and number as shown on the Plans.

714.10 Luminaires

Install luminaires of the design and size shown on the Plans, and level according to the manufacturer's recommendations, as shown on the Plans and as approved by the Engineer. Provide glare shields on luminaires when shown on the Plans.

Clamp the pole and bracket cable in the proper terminals on the terminal board in the luminaire, and then splice the cable to the proper phase and neutral conductors outside of the handhole in the pole base. After other required circuit splices are made outside of the handhole, place all of the wire inside the handhole. Leave slack in all cables for future maintenance. Attach a suitable identification tag to each of the phase cables.

Clean luminaire reflector surfaces and glassware after installation. Perform cleaning, if required, according to the luminaire manufacturer's recommendations.

Ensure that luminaires for sign lighting are adjustable both horizontally and vertically.

714.11 Lamps

Install lamps of the design, type, and size, and at the locations shown on the Plans.

714.12 Installation of Overhead Wires

Install overhead wiring, when specified, as shown on the Plans.

714.13 Cable Markers

When shown on the Plans, place precast or cast-in-place concrete cable markers, of the dimensions indicated, at all locations where lighting cables make an abrupt change in direction. Construct the markers of Class A concrete meeting **604**. Imprint an arrow on each marker to indicate the direction of the cable run as it approaches and leaves the marker. Also imprint the circuit number on the marker.

Recess the markers into the ground approximately 3 inches, unless otherwise specified.

714.14 Control Center

Furnish and install a service pole or poles of the design, type, size, and class, and at the locations shown on the Plans. Install the service pole(s) as specified in **714.08** and as shown on the Plans. Set the service pole(s) plumb.

Notify the power company, at least 30 days before connection, of the need to furnish power to operate the lighting system.

Unless otherwise specified, furnish and install all the control center equipment and electrical supply facilities. The electrical supply facilities shall include the necessary service conduit from the control cabinet to the delivery point designated on the Plans.

Construct a concrete slab, of the dimensions and thickness indicated, around the service pole foundation. Construct the slab of Class A concrete meeting the requirements of **604**, and reinforce the slab, if specified, as shown on the Plans.

Construct a 6-foot chain-link fence and gate of the size specified around the control center as shown on the Plans and as specified in **707**.

714.15 Field Painting

After erection is completed, thoroughly clean steel standards that are not galvanized, and then apply two coats of inorganic zinc paint meeting the requirements of **910.03**. Perform painting as specified in **603**.

If the shop coat of prime paint is damaged, cover the damaged areas with a coat of the same type of paint as used for the original primer coat, and allow it to completely dry before applying the first coat of aluminum paint.

If the finish on galvanized steel materials is scratched, chipped, or otherwise damaged, the Engineer will reject the material, or may allow the Contractor to repair it as specified in **713.04.B**.

714.16 Testing After Installation

Install all materials and equipment to form a complete installation ready for operation, unless otherwise specified.

After the installation is completed, test the lighting system in the presence of a Department representative and the Maintaining Agency. Tests shall include insulation resistance, voltage, current, and performance tests. Unless otherwise specified, perform the tests in accordance with the following:

A. Voltage Tests

Take a voltage reading at the control center at the load side of the circuit protection device and the last lighting standard served in each branch circuit. In cases where the circuit feeds in two or more directions, take the voltage reading at the light most remote from the control point or as directed by the Engineer. Unless otherwise specified, with the complete lighting system energized and all lamps operating, the voltage of this last standard shall not be less than 90% of the nominal rated voltage of the luminaire supply circuit, and the voltage at the last underpass luminaire in each branch circuit shall not be less than the minimum operating voltage recommended by the manufacturer of the luminaire ballast.

B. Current Test

Conduct current tests at each control center at the load side of each circuit protection device, using a clamp-on type ammeter. Current, in amperes, in each supply conductor shall not be greater than the rated current of a luminaire times the number of luminaires in the circuit.

C. Grounding Resistance Test

Conduct ground resistance tests with a "megger," manufactured by the James H. Biddle Company, or a "vibraground" manufactured by Associated Research Incorporated or approved equal.

Adhere to the following when conducting this test:

1. Ensure that no equipment, such as ballast or oil switches, is connected at the time of the test.
2. Test only one conductor at a time.
3. Isolate the conductor being tested from ground.
4. Ensure that the other phase conductor and the neutral are grounded during each test.

D. Performance Tests

Prior to acceptance and after all faults have been corrected, the Contractor shall operate the lighting system, including automatic control equipment and other specified apparatus, for a continuous 48-hour period without interruption or failure attributable to poor workmanship or defective material. After the 48 hours of continuous

operation, the Engineer will inspect all lights and equipment for normal operation. Make all necessary repairs or replacements to the Engineer's satisfaction.

Make arrangements with the Servicing Agency to purchase the electric power necessary to conduct all tests.

Furnish the Engineer five copies of the test results, together with five copies of a statement from the Maintaining Agency that the system is acceptable to the Agency.

714.17 Repair of Seeded and Sodded Areas

If areas previously seeded or sodded are disturbed during the performance of the work described in this Section, reseed (with mulch) or re-sod such areas as specified in **801** or **803**, respectively. Perform these repairs as the work progresses to minimize erosion of disturbed areas.

714.18 Disposal of Excess or Unsuitable Material

Dispose of excess or unsuitable material as specified in **203.07**.

714.19 Final Cleanup

Perform final cleanup as specified in **104.10**. Remove existing foundations, designated for removal, to a minimum of 6 inches below grade. Before final inspection, touch-up finishes, clean surfaces including signs that are lighted, and perform such other work as directed by the Engineer to ensure the effectiveness and neat appearance of the work.

COMPENSATION

714.20 Method of Measurement

When the bid schedule contains an item for Roadway and Structure Lighting on a lump sum basis, measurement will be for the sum total of all items to be furnished and installed.

When the bid schedule contains items for various elements of Roadway and Structure Lighting, the Department will make measurement for payment as follows:

A. Conduit

The Department will measure:

1. Encased Conduit and Direct Burial Conduit by the linear foot of conduit for each kind, number, and size installed as indicated, and

2. Conduit (Structures) of the kind and size specified by the linear foot of each individual kind and size of conduit placed.

B. Pull Boxes

The Department will measure Pull Boxes by the unit, per each.

C. Cable

The Department will measure Cable of the type, and number and size of conductors specified, by the linear foot from the center to center of pull boxes, light standards, and similar features, for each type and number and size of conductors. No additional allowance will be made for slack length, length inside equipment or standards, and similar instances requiring additional length of wire.

D. Preassembled Cable in Duct

The Department will measure Preassembled Cable in Duct by the linear foot from the center to center of pull boxes, light standards, and similar features. No additional allowance will be made for slack length.

E. Light Standards

The Department will measure Light Standards of the kind and design specified by the unit, per each.

F. Luminaires

The Department will measure Luminaires of the size, type, and design specified by the unit, per each.

G. Overhead Conductors

The Department will measure Overhead Conductors of the gauge, type, and kind specified by the linear foot between supports. No allowance will be made for slack length.

H. Cable Markers

The Department will measure Cable Markers by the unit, per each.

I. Control Center

The Department will measure the Control Center on a lump sum basis. Such measurement will be for the sum total of all items to be furnished and installed at the control center, except as specified in **714.20.J** and **714.20.K**.

J. Class A Concrete

The Department will measure Class A Concrete used to construct the concrete slab around the service pole at the control center by the volume in cubic yards, as determined from the specified thickness shown on the Plans and surface measurements for width and length. The Department will not measure reinforcement for the concrete slab for payment, but will consider the costs thereof as incidental to the item for Class A Concrete.

K. Chain-Link Fence and Gate

The Department will measure and pay for Fence and Gates in accordance with **707.08** and **707.09**, respectively.

L. Navigational Lighting and Overhead Sign Lighting

The Department will measure Navigational Lighting and Overhead Sign Lighting furnished and installed in accordance with the Plans on a lump sum basis.

M. Incidental Items

The Department will consider incidental, and will not directly measure, the following:

1. Excavation and backfilling performed in connection with this construction.

2. The removal and satisfactory disposal of existing pavement, surface, and base required to install conduit, and for restoring the base, pavement, and surface to their original condition.

3. Furnishing, installing, and subsequently removing sheeting, bracing, and supports needed to install conduit.

4. Labor, materials, equipment, electrical energy, and incidentals required to conduct the performance tests specified in **714.16.D**.

5. Reseeding, resodding, and otherwise restoring to their original condition areas that were disturbed during the performance of the work described in this Section.

714.21 Basis of Payment

When the bid schedule indicates payment will be made for Roadway and Structure Lighting on a lump sum basis, such payment is full compensation for all materials, labor, equipment, and incidentals necessary to produce a completely integrated, operative, and finished installation of a Roadway and Structure Lighting System, as shown on the Plans.

When the bid schedule contains items for various elements of Roadway and Structure Lighting, the Department will make payment as follows:

A. Conduit

1. Encased Conduit. The Department will pay for Encased Conduit at the contract unit price per linear foot, complete in place, for each kind, number, and size installed as indicated. Such payment is full compensation for all excavation, sheeting when required, backfilling, disposal of excess or unsuitable material, furnishing and placing or installing all materials and accessories, including grounding materials, concrete, and reinforcement when specified, all bends, joints, fittings and appurtenances, and installing the encased conduit complete.

2. Direct Burial Conduit. The Department will pay for Direct Burial Conduit of the kind, number, and size specified at the

contract unit price per linear foot, complete in place. Such payment is full compensation for all excavation, sheeting when required, backfilling, jacking of conduit, disposal of excess or unsuitable material, furnishing and placing or installing all materials and accessories, including grounding materials, bedding materials when required, all bends, joints, fittings and appurtenances, and installing the conduit complete.

3. **Conduit (Structures).** The Department will pay for Conduit (Structures) of the kind and size specified at the contract unit price per linear foot, complete in place. Such payment is full compensation for furnishing and installing all materials, including conduits, hangers, expansion fittings, grounding materials, and associated hardware and accessories, and installing the conduit complete.

B. Pull Boxes

The Department will pay for Pull Boxes at the unit price per each, complete in place. Such payment is full compensation for furnishing and installing or constructing pull boxes and for all excavation, backfilling, and other work connected therewith.

C. Cable

The Department will pay for Cable of the type, and number and size of conductors, as specified, at the contract unit price per linear foot, complete in place. Such payment is full compensation for furnishing and installing the cable and grounding materials, making splices, joints and connections, and for trenching, furnishing, and placing cushion and backfill material, and disposing of excess or unsuitable excavated material.

D. Preassembled Cable in Duct

Preassembled Cable in Duct of the kind and size specified will be paid for at the contract unit price per linear foot, complete in place. Such payment is full compensation for furnishing and installing the cable duct, grounding materials, making splices and connections, and for trenching, furnishing, and placing cushion and backfill material, and disposing of excess or unsuitable excavated material.

E. Light Standards

The Department will pay for Light Standards of the type specified at the contract unit price per each, complete in place. Such payment is full compensation for furnishing and installing the complete light standards, including the foundation, standard, bracket arm or arms, associated hardware and wiring, grounding materials, excavation, backfilling materials, and backfilling. The Department will measure foundations for high mast towers separately.

F. Luminaires

The Department will pay for Luminaires of the size and type specified at the contract unit price per each, complete in place. Such payment is full compensation for furnishing and installing the complete luminaire, including the ballast(s), lamp(s), glare shields where required, and associated hardware and wiring.

G. Overhead Conductors

The Department will pay for Overhead Conductors of the gauge, type, and kind specified at the contract unit price per linear foot, complete in place.

H. Cable Markers

The Department will pay for Cable Markers of the design specified at the contract unit price per each, complete in place. Such payment is full compensation for furnishing and installing the marker complete, including the excavation, backfilling, and removal and disposal of excess or unsuitable excavated materials.

I. Control Center

The Department will pay for the Control Center at the contract unit price per lump sum, complete in place. Such payment is full compensation for furnishing and installing all equipment and materials, including service pole(s) when specified, and photoelectric relays, relay cabinets, multiple relays, lightning arrestors, fuse cutouts, and all other equipment, materials, associated hardware, and accessories, as shown on the Plans. Payment for the Control Center is full compensation for furnishing and installing all electrical supply facilities from the delivery point for electrical energy, as shown on the Plans, to the control center.

J. Class A Concrete

The Department will pay for Class A Concrete, measured as specified in **714.20.J**, at the contract unit price per cubic yard, complete in place.

K. Navigational Lighting and Overhead Structure Lighting

The Department will pay for Navigational Lighting and Overhead Structure Lighting by the lump sum complete in place including all materials and labor.

SECTION 715 – ASPHALTIC CONCRETE CURB (HOT MIX)

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715.09 Curing and Protection 804
715.10 Method of Measurement 804
715.11 Basis of Payment 804

DESCRIPTION

715.01 Description

This work consists of constructing an asphaltic concrete curb composed of a mixture of coarse aggregate, fine aggregate, mineral filler (if specified or required), and asphalt cement, on a prepared foundation.

MATERIALS

715.02 Materials

Provide materials meeting **411.02**, except that commercially available stabilizing material may be added with the Engineer's approval.

715.03 Composition of Mixture

The composition of the mixture shall conform to the requirements of **411.03** with the following additions and revisions:

A. Proportioning

Combine the mineral aggregate and asphalt cement as specified in Table 715.03-1.

Table 715.03-1: Proportioning

Combined Mineral Aggregate	Asphalt Cement
90-94%	6-10%

B. Mineral Aggregate

Use mineral aggregate of Grading E, except that other gradings that have a history of satisfactory performance may be used when approved by the Engineer.

C. Job Mix Formula

Use a job mix formula that will provide sufficient workability during placing and that will ensure a finished curb of adequate stability and the desired surface texture.

EQUIPMENT

715.04 Equipment

Use mixing and hauling equipment that meet **407.04** and **407.05**.

To place the curb, use an approved self-propelled automatic curb machine capable of producing a smooth, well-compacted finished curb. Equip the machine with a hopper sufficient in capacity to ensure a continuous operation, and a power driven screw or other device that forces the mixture through a tube and then through a die or mold attached to the tube. Ensure that the mold will produce the desired cross-section of the curb. The machine shall be so constructed that the thrust against the asphaltic mixture will eliminate objectionable surface voids as the mixture passes through the mold.

CONSTRUCTION REQUIREMENTS

715.05 Limitations

Comply with **407.09**.

715.06 Preparing the Curb Foundation

When the curb is to be placed on a granular base, remove all soft or otherwise unsuitable material and replace with suitable material. Thoroughly compact the finished base, and shape to the required line, grade, and cross-section, and prime in accordance with the applicable provisions of **402**.

When the curb is to be placed on an existing pavement, thoroughly clean the area receiving the curb of all dirt and other objectionable matter. Apply a tack coat to this area in accordance with the applicable provisions of **403.**

715.07 Preparing the Mixture

Prepare the asphaltic concrete curb mixture as specified in **407.11**, **407.12**, and **407.13**.

715.08 Hauling and Placing Mixture

Use hauling equipment of an approved type, and schedule hauls so that the temperature of mixture when deposited is not more than 25 °F lower than when it left the mixing plant.

Place the curb in position on the tacked or primed surface using an approved automatic curb machine that shapes and compacts the mixture to the designated cross-section. No side forms will be required for machine placed curb, but where the curb is laid on an existing pavement that does not have a smooth grade, the Engineer may require use of a 2 x 2 inch angle iron or other approved apparatus as a track so that the finished curb will have a smooth and true line and grade.

Where the curb is to abut an existing structure-wall or is placed at the extreme edge of pavement, use a machine that is capable of placing the curb within 1 inch of the structure-wall or pavement edge. Only use hand methods adjacent to structures that preclude machine placing.

On grades greater than 3%, place the curb with the machine traveling uphill. If, in the Engineer's opinion, the curb is not being adequately compacted, take corrective action. Corrective measures may include adjusting the mix, loading the machine with additional weight, retarding forward movement of the machine by braking, or other measures that will ensure adequate compaction.

Carefully construct required joints so as to ensure a continuous bond between the old and the new sections of the curb.

715.09 Curing and Protection

Protect the newly laid curb from traffic by barricades or other suitable methods until the asphaltic mixture has cooled to air temperature.

Remove and replace curb or sections of curb that are displaced, destroyed, or otherwise damaged before final acceptance.

715.10 Method of Measurement

The Department will measure Asphalt Concrete Curb for payment by the linear foot, complete in place.

715.11 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Asphaltic Concrete Curb (__ inches)	Linear Feet

SECTION 716 – PAVEMENT MARKINGS

716.01 Description 805
716.02 Materials 805
716.03 Thermoplastic Pavement Marking 806
716.04 Raised Reflective Pavement Markers 811
716.05 Snowplowable Reflective Pavement Marker 813
716.06 Preformed Plastic Pavement Markings 813
716.07 Paint 814
716.08 Method of Measurement 817
716.09 Basis of Payment 819

DESCRIPTION

716.01 Description

This work consists of furnishing and supplying pavement markings in accordance with these Specifications and the latest revision of the MUTCD, including establishing and locating non-passing zones as well as providing the layout of paint striping, preformed plastic pavement markings, raised reflective pavement markers, snowplowable reflective pavement markers, and thermoplastic pavement markings.

MATERIALS

716.02 Materials

Provide materials as specified in:

Paint **910**
Thermoplastic Pavement Markings **919.01**
Spray Thermoplastic Pavement Marking **919.02**
Preformed Plastic Pavement Marking **919.03**
Raised Reflective Pavement Markers **919.04**
Snowplowable Reflective Pavement Markers **919.05**

Plastic pavement markings may be either preformed or thermoplastic unless otherwise specified.

CONSTRUCTION REQUIREMENTS

716.03 Thermoplastic Pavement Marking

Furnish and apply thermoplastic pavement marking material meeting **919.01** by the screed extrusion or ribbon dispenser methods, or spray thermoplastic pavement marking material meeting **919.02**.

As an alternate, the Contractor may apply preformed thermoplastic marking material for stop bars, cross walks, legends, or directional arrows. The preformed thermoplastic material shall have a minimum thickness of 0.090 inches and be fused to the pavement by the heat of a torch.

A. Equipment

Provide special kettle(s) for melting and heating the thermoplastic material. Equip the kettle(s) with automatic thermostatic control devices so that heating can be done by controlled heat transfer rather than by direct flame, to provide positive temperature control and prevent over-heating of the material.

Provide equipment that will continuously mix and agitate the material. Conveying parts of the equipment shall prevent accumulation and clogging. All parts of the equipment that come in contact with the material shall be easily accessible for cleaning and maintenance. All mixing and conveying parts of the equipment, including the shaping die (or spray nozzle in the case of spray thermoplastic marking material), shall maintain the material at the plastic temperature with heat transfer oil or electrical element controlled heat. Direct fire heat transfer will not be allowed.

The equipment shall ensure continuous uniformity in the dimensions of the stripe. The applicator equipment shall be mobile and maneuverable to the extent the straight line can be followed and normal curves can be made in a true arc. The applicator equipment shall provide a method of applying “skip” lines. Calibrate the equipment, and check it periodically by marking over a metal plate. The equipment shall provide for varying widths to produce varying widths of traffic markings.

1. **Extruded or Ribbon-Dispensed Thermoplastic Marking.** Apply the material to the pavement by either the screed extrusion method or the ribbon dispenser method.

   The screed extrusion device shall have one side of the shaping die open with the other three sides contained by, or part of, suitable equipment for heating and controlling the flow of material. Do not use pans, aprons, or similar appliances that the die overruns.

   Ribbon dispensers shall be heated, suspended above the road surface, and shall apply the material to the width and thickness specified.

   Apply glass spheres to the surface of the completed stripe by an automatic bead dispenser attached to the striping machine in such a manner that the beads are dispensed almost instantaneously upon the installed line. The glass sphere dispenser shall be capable of applying glass spheres to the surface of the completed stripe by a double drop application for initial traffic striping and marking. Attach the bead dispenser for the first bead drop to the striping machine so that the beads are dispensed closely behind with the thermoplastic material. Attach the second bead dispenser to the striping machine so that the beads are dispensed immediately after the first bead drop application. Equip glass sphere dispensers with an automatic cut-off control that is synchronized with the cut-off of the thermoplastic material and applies the glass spheres so that the spheres appear uniform on the entire traffic stripes and markings surface with 50 to 60% embedment.

   The applicator equipment to be used on roadway installations may consist of either hand equipment or truck mounted units depending on the type of marking required.

   The hand equipment shall have sufficient capacity to hold 150 pounds of molten material and shall be sufficiently maneuverable to install crosswalks, lane, edge, and center lines, arrows, and legends. The truck mounted unit for lane, edge, and center lines shall consist of a mobile self-contained unit carrying its own material capable of operating at a minimum speed of 5 miles per hour continuously during an 8-hour period while installing striping.

Hand equipment used for stop bars, cross walks, legends, directional arrows and other specialty markings shall use the same thermoplastic formulation as described above with the exception of placing the marking at a minimum thickness of 0.090 inches and a single drop of AASHTO M 247, Type 1 bead at the rate of 8 to 10 pounds per 100 square feet of stripe.

2. **Spray Thermoplastic Marking.** For lane, edge, and center lines, use truck-mounted applicator equipment consisting of a mobile self-contained unit carrying its own material capable of operating at a minimum speed of 5 miles per hour continuously during an 8-hour period while installing striping.

   Each application machine must be equipped with an automatic counting mechanism capable of recording the number of linear feet of material applied to the roadway surface with an accuracy of 0.50%, to be checked by the Engineer.

   Apply glass spheres to the surface of the completed stripe by an automatic bead dispenser attached to the striping machine in such a manner that the beads are dispensed almost instantaneously upon the installed line. The glass sphere dispenser cut-off shall be synchronized with automatic cut-off of the thermoplastic material.

B. Application

1. **Contractor's Responsibility for Notification.** Notify the Engineer before placing the thermoplastic materials. Furnish the Engineer with the manufacturer's name and batch numbers of the thermoplastic materials and glass spheres to be used. Ensure that the approved batch numbers appear on the thermoplastic materials and glass spheres packages.

2. **Application.** Before beginning application, ensure that the pavement temperature is a minimum of 50 °F and rising. Suspend application if the pavement temperature falls below 50 °F. Thoroughly clean all surfaces to be marked of all dust, dirt, grease, oil, and all other foreign matter before applying the striping.

   The pavement marking material, when formed into traffic stripes, shall be readily renewable by placing an overlay of new material directly over old markings of the same material. Such new

material shall bond itself to the old markings in a manner that will ensure no splitting or separation will take place.

Offset longitudinal lines at least 2 inches from longitudinal joints of Portland cement concrete pavements.

a. Extruded or Ribbon-Dispensed Thermoplastic Marking. To ensure optimum adhesion of thermoplastic applied on all Portland cement concrete pavements, apply a binder-sealer material as recommended by the thermoplastic manufacturer. To ensure optimum adhesion, install the thermoplastic material in a melted state at a temperature of 400 to 450 °F.

Unless otherwise shown on the Plans, maintain a minimum average film thickness of 0.100 inch for lane and edge lines on all markings. Compute this thickness on the basis of the amount of material used each day. The film thickness shall be uniform in appearance throughout its application. Apply the glass sphere top coating with a pressure type spray gun designed specifically for this purpose, and that will embed the spheres into the line surface to at least one-half their diameter.

Place Drop on Glass Beads of AASHTO M 247 Type 1 and Type 4 on the thermoplastic stripe at a rate of 8 to 10 pounds per 100 square feet of stripe.

Place the AASHTO M 247 Type 4 glass beads immediately after the first bead drop application of AASHTO M 247 Type 1 beads.

Regardless of the application methods and procedures, or pavement types, replace all pavement markings that fail to comply with these Specifications, or fail to adhere to the pavement for one year after installation, at no cost to the Department.

b. Spray Thermoplastic Marking. Before applying the pavement-marking material, remove all dirt, glaze, grease, and all other material that would reduce the adhesion of the paint to the pavement. Open-graded roadways, such as double-bituminous surface treatment (DBST), require sweeping (brooming) to ensure cleanliness.

Remove all existing material that might cause premature failure of the new material.

To ensure optimum adhesion of spray thermoplastic applied to Portland cement concrete surfaces, apply a binder-sealer material as recommended by the thermoplastic manufacturer.

The binder-sealer material shall form, when applied with conventional mobile paint spraying equipment, a continuous film over the pavement surface that will dry rapidly and adhere to the pavement surface. The binder-sealer shall be that product currently in use and recommended by the thermoplastic material manufacturer. Include all costs, including materials, associated with application of the binder-sealer, in the unit bid price for the spray thermoplastic pavement markings.

Install the pavement-marking material in a molten state, by the spray method, at a minimum temperature of 350 °F and a maximum temperature of 425 °F. Scorching or discoloration of material is cause for rejection by the Engineer. Use equipment constructed so that all mixing and conveying parts, up to and including the spray gun, maintain the material in the molten state.

Do not apply the pavement-marking materials when air and pavement surface temperatures are below 40 °F or when the surface of the pavement contains evidence of moisture.

When the plans specify 60-mil markings, apply the pavement-marking material at a thickness of not less than 0.060 inch for all roads except open-graded roadways such as DBST. For such surfaces, apply material at a thickness of not less than 0.065 inch. In no case shall the applied thickness exceed 0.075 inch.

Place the pavement-markings with adequate drop-on glass spheres in accordance with the above requirements, uniformly applied to ensure adequate nighttime reflectivity. Use a compatible combination of marking material and spheres to preclude the surface spheres from sinking deeply into the marking, or from being prematurely lost from the surface of the marking.

The producers of the thermoplastic compound and glass spheres shall furnish to the Department three copies of certified tests reports showing results of all tests specified therein and shall further certify that the materials meet all requirements.

The Department will randomly sample molten thermoplastic material for verification testing in accordance with AASHTO T 250.

3. **Temporary Marking.** When thermoplastic is used on the final surface, the Contractor may use reflectorized paint installed to permanent standards at the end of each day's work and then install the permanent marking after the paving operation is completed. Short, unmarked sections are not allowed. The Department will not directly measure and pay for temporary markings for the final surface, and will consider the costs thereof to be incidental to the item for permanent markings.

4. **Protection of Newly Applied Traffic Stripes and Markings.** Do not allow traffic onto or allow vehicles to cross newly applied pavement markings until they are sufficiently dry. Remove and replace portions of the pavement markings damaged by passing traffic or from any other cause, at no additional cost to the Department.

716.04 Raised Reflective Pavement Markers

To bond markers to the pavement, use an epoxy listed on the Department's QPL and that is approved by the marker manufacturer or a hot bituminous adhesive conforming to the requirements specified below. Do not use markers manufactured with a self-adhesive backing. Space markers as shown on the Plans. Do not install markers over joints in rigid pavements.

Furnish pavement markers of a type listed on the Department's QPL. Install the markers when the pavement is dry and the pavement temperature is no less than 50 °F.

Clean the portion of the highway surface, to which the marker is to be bonded by the adhesive, of all dirt, curing compound, grease, oil, moisture, loose or unsound layers, paint, and all other material that would adversely affect the bond of the adhesive. Perform cleaning by blast cleaning on Portland cement concrete and old bituminous pavements. Blast clean new bituminous pavement where, in the Engineer's judgment, the surface contains an abnormal amount of asphalt or the surface is contaminated with dirt, grease, paint, oil, or other material that would adversely affect the bond of the adhesive.

Melt and heat the bituminous adhesive in either thermostatically controlled double boiler type units using heat transfer oil or thermostatically controlled electric heating pots. Do not use direct flame melting units. Use a melter/applicator unit that is suited for both melting and pumping application through heated applicator hoses.

Heat the adhesive to between 375 and 425 °F, and apply it directly to the pavement surface from the melter/applicator by either pumping or pouring. Maintain the application temperature between 375 and 425 °F, as lower temperatures may result in decreased adhesion while higher temperatures may damage the adhesive.

Apply the adhesive in a puddle approximately 2/3 to 3/4 the diameter of the marker. Apply markers to the adhesive immediately (within 10 seconds) to ensure bonding. Place the marker in position by applying downward pressure until the marker is firmly seated with the required adhesive thickness and squeeze out. Remove excessive adhesive squeeze out from the pavement, and immediately remove adhesive on the exposed surfaces of the markers. Remove adhesive from exposed faces of pavement markers according to manufacturer's recommendations.

Install reflective markers so that the reflective face of the marker is perpendicular to a line parallel to the roadway centerline. Protect the markers against impact until the adhesive has hardened to the degree designated by the Engineer.

The Contractor may reheat and reuse adhesive, provided the manufacturer's recommendations regarding the pot life at application temperatures are not exceeded.

Clean out equipment and tanks using petroleum solvents such as diesel fuel or similar materials. Turn off all heating equipment before beginning cleaning operations. Remove all solvent from the equipment tanks and lines before the next use of the melter.

716.05 Snowplowable Reflective Pavement Marker

Contour the pavement at each snowplowable marker location to match the bottom of the marker casting. Install markers according to the manufacturer's recommendations. When using the dry saw method, provide a vacuum system to contain the dust. Regardless of the saw method used, ensure that the saw cut is clean, dry, and free of all dust or residue before applying the adhesive. Accompany each shipment of adhesive with a written statement from the adhesive manufacturer certifying that the material furnished conforms to the recommendations of the marker manufacturer, and stating the minimum temperature at which the adhesive can be satisfactorily mixed and applied.

716.06 Preformed Plastic Pavement Markings

Apply preformed plastic pavement markings on clean, dry surfaces free of dirt and foreign matter. Only apply markings when the pavement temperature is at least 60 °F. Should the plastic require activators for the adhesive or various special coatings for different pavement surfaces, include the cost of the activator or special coatings in the unit price of plastic.

Furnish with each package of reflectorized pavement marking materials complete instructions and specifications for applying pavement marking materials to pavement surface. Install the reflectorized pavement marking materials according to the vendor's specifications. Any adhesion used in the installation shall be as specified by the manufacturer. Use an adhesion-promoting primer when recommended by the pavement marking manufacturer.

Establish guides to mark the lateral location of pavement markings as shown on the Plans or as directed by the Engineer. The Engineer will verify the location of the guides. Place markings in proper alignment with the guides. The deviation rate in alignment shall not exceed 1 inch per 200 feet of roadway. The maximum deviation shall not exceed 2 inches, and there shall be no abrupt deviations.

Remove and replace, at no cost to the Department, markings placed that are not in the alignment or sequence as shown on the Plans or as specified

herein. Remove such markings as specified in **712.05**. Guides placed on the roadway for alignment purposes shall not establish a permanent marking on the roadway in the opinion of the Engineer.

When specified in the Contract, place markings for newly paved asphalt concrete surfaces immediately after final rolling of the mat. Use a rubber tired roller cart with a minimum weight of 200 pounds or a truck operated at no more than 3 miles per hour to ensure proper adhesion when the markings are in place. Do not use steel wheel rollers for this purpose.

716.07 Paint

A. Application of Painted Pavement Markings

Apply paint with a spray-type machine capable of satisfactorily applying the paint under pressure through a nozzle that sprays directly upon the pavement at a rate not to exceed 880 feet per minute. Equip the machine with:

1. Air blast device for cleaning the pavement ahead of the painting operation;

2. Guide pointer to keep the machine on an accurate line;

3. Device to agitate the paint;

4. Device to maintain a uniform flow and application of the paint;

5. Automatic device to provide a broken or skip line of the length required;

6. At least two spray guns capable of being operated either individually or together;

7. Automatic counting mechanism capable of recording the number of linear feet of material applied to the roadway surface with an accuracy of 0.50%, to be checked by the Engineer; and

8. Accurate meters that register quantities for both white and yellow applied paint to the nearest gallon.

When using waterborne paint, ensure the equipment is capable of heating the material from ambient air temperature to 123 °F. Equip the machine with a bead or sphere dispenser that can be regulated to dispense the spheres automatically at the uniform rate required. The equipment shall be designed and operated so as to allow traffic to safely pass on the roadbed.

Do not apply paint unless the ambient air temperature is at least 45 °F. However, if the Engineer directs that paint be applied when air temperatures are below 45 °F, heat the paint according to the manufacturer's recommendations.

For the following operations, the Engineer will not require large automatic spray application machinery meeting the preceding requirements, provided the Contractor selects pavement marking equipment capable of producing a uniform, acceptable finished product consistent with the Plans and Specifications:

1. Installation of temporary pavement markings.

2. Installation of permanent pavement markings on projects having a total length of 1,000 feet or less.

3. Installation of permanent pavement markings on an individual project segment having a total length of 1,000 feet or less on an intermittent project.

Clean the pavement surface before placing any pavement marking material.

Locate and place temporary markings on final pavement surfaces so as to underlie or coincide with the permanent pavement markings.

Perform cleaning and painting using equipment of the kind and in the manner provided by previously specified equipment. On sections where no previously applied line is available to serve as a guide or if the line is to be re-located, spot the proposed location of the new line with paint in advance of the application. On tangent sections, space the control points no more than 500 feet apart and on curves at intervals that will ensure the accurate location of the line. Leave gaps in all lines at intersections in accordance with the MUTCD or as directed by the Engineer.

Do not apply any paint over a chalk line, wire, or cord, and instead offset such guide marks from the paint line to be placed. On sections where previously applied lines are visible, use the old lines unless otherwise directed. Do not apply any paint to areas of pavement when moisture remains on the surface, or when wind conditions may cause a film of dust to be deposited on the line areas after these areas have been prepared for painting.

Apply drop-on type glass beads uniformly to the painted surface at a uniform rate of not less than 6 pounds per gallon of paint applied.

Apply paint so as to deposit a uniform wet film thickness of 0.015 inch (within a reasonable tolerance) and at a speed not to exceed 880 feet per minute. This is at the rate of 17 gallons per mile for a solid stripe 4 inches wide. Use this rate of application for all types of paint, making proper adjustments in gallons for an intermittent line or wider lines. Ensure that the quantity of paint does not under-run the designated amount by more than 5%. If a check of the rate of application indicates a greater variation, stop the work until the paint machine is properly adjusted or replaced. This percent of variation is set out to give the Contractor some leeway in starting the job and in getting the machine in adjustment; it is not expected that there will be either a continuous overrun or under-run, but that the final average rate of application will closely approach the rate established above.

When reflectorized paint is required for temporary or final marking, install the paint to permanent standards at the end of each day's work. Do not leave any short, unmarked sections.

Protect traffic lines and markings. Place warning and directional signs as shown on the Plans or as directed by the Engineer to control traffic in the marking area. If the drying time of the material being used exceeds 60 seconds, protect the newly applied markings by placing traffic cones or other approved warning devices at frequent intervals as directed. Leave these devices on the line until the material is dry or firm enough not to track or receive impressions from normal traffic. Remove these devices as soon as possible to prevent a traffic hazard. Do not leave such devices in the roadway overnight. If so directed, provide flaggers to direct traffic.

Apply paint to appear as clearly delineated lines with minimal crookedness and waviness, giving due consideration to the contours and roughness of the pavement. Segments of broken line stripe shall

square off positively at each end. The paint lines shall be without mist, drip, or splatter. Remove and/or correct, to the Engineer's satisfaction and at no additional cost to the Department, lines that do not meet these requirements when placed.

Operate the paint equipment so that it will be unnecessary for traffic to cross the newly painted line behind the equipment in order to safely pass the painting machine, and so as to allow traffic to keep moving at all times.

B. Removal of Painted Markings

Remove painted pavement markings where specified or directed by the Engineer. Obtain the Engineer's approval of the paint removal method before beginning the work. Do not remove existing painted pavement markings by painting over them with black paint or asphalt.

When the method of removal causes sand or other material to accumulate on the pavement, remove the residue as the work progresses. Remove painted markings by methods that cause the least possible damage to the pavement. Repair damage to the pavement or surface caused by pavement marking removal as directed by the Engineer and at no cost to the Department.

Where a plastic marking will replace the painted marking and paint removal is specified in the Contract, remove enough of the paint to ensure proper installation of the plastic. The paint removal shall be uniform and shall expose a minimum of 75% of the surface area that is to receive the plastic materials.

COMPENSATION

716.08 Method of Measurement

A. Pavement Marking (Broken lane lines), Pavement Marking (Dotted line), and Pavement Marking (Transverse Shoulder)

The Department will measure the length of each of these markings, complete in place and accepted, as listed in the bid schedule, along the center of each line. Only the marked line will be measured for payment.

B. Pavement Marking (Solid barrier line)

The Department will measure the length of solid barrier line, complete in place and accepted, along the center of each line. Where double solid barrier lines are used, each solid barrier line will be measured separately for payment.

C. Pavement Marking (Crosswalk Striping)

The Department will measure the length of crosswalk striping, complete in place and accepted, along the centerline of the crosswalk. The Department will not separately measure boundary lines on crosswalk.

D. Pavement Marking (Channelization Striping)

The Department will measure Channelization Striping, including the boundary lines, complete in place and accepted, by the square yard.

E. Pavement Marking (Stop line)

The Department will measure the length of stop lines, complete in place and accepted, in linear feet to the nearest foot along the centerline of the stop line.

F. Pavement Marking (Designs)

The Department will measure designs or lettering by the unit, per each, complete in place or as stipulated in the Contract and shown on the Plans.

G. Raised Reflective Pavement Markers and Snowplowable Reflective Pavement Markers

The Department will count the number of each type of pavement markers installed as directed and accepted.

H. Removal of Existing Painted Line

The Department will measure the removal of broken lane line and solid barrier line along the center of each line. Only the painted line will be measured for payment.

Adhesives will be considered incidental to the installation of raised reflective pavement markers and snowplowable reflective pavement markers.

716.09 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Plastic Pavement Marking (__" Dotted Line)	Linear Feet
Plastic Pavement Marking (Transverse Shoulder)	Linear Feet
Plastic Pavement Marking (__" Barrier Line)	Linear Feet
Plastic Pavement Marking (Cross-Walk)	Linear Feet
Plastic Pavement Marking (Stop Line)	Linear Feet
Plastic Pavement Marking (Channelization Striping)	Square Yard
Painted Pavement Marking (__" Barrier Line)	Linear Feet
Painted Pavement Marking (Cross-Walk)	Linear Feet
Painted Pavement Marking (Stop Line)	Linear Feet
Painted Pavement Marking (Channelization Striping)	Square Yard
Plastic Pavement Marking (Word or Design)	Each
Raised Pavement Marker (Description)	Each
Snowplowable Pavement Marker (Description)	Each
Removal of:	
Pavement Marking (Dotted Line)	Linear Feet
Pavement Marking (Transverse Shoulder)	Linear Feet
Pavement Marking (__" Barrier Line)	Linear Feet
Pavement Marking (Cross-Walk)	Linear Feet
Pavement Marking (Stop Line)	Linear Feet
Pavement Marking (Channelization Striping)	Square Yard
Pavement Marking (Word or Design)	Each

Such payment is full compensation for layout, materials, labor, equipment, tools, royalties, and all other incidentals necessary to complete the work.

SECTION 717 – MOBILIZATION OF FORCES, SUPPLIES AND EQUIPMENT

717.01 Description 820
717.02 Method of Measurement 820
717.03 Basis of Payment 820

DESCRIPTION

717.01 Description

This work consists of mobilizing and demobilizing the prime Contractor's and all Subcontractors' forces, supplies, equipment, and incidentals at the Project site. It shall include all Contractor and Subcontractor costs associated with obtaining performance bonds, insurance required by railroads, and other preconstruction costs incurred after Contract award that are necessary costs to the Project and are of a general nature rather than directly attributable to other pay items. Include all necessary preconstruction costs not attributable to a specific pay item in the lump sum price for Mobilization and not in any other pay item.

COMPENSATION

717.02 Method of Measurement

The Department will measure Mobilization by the unit for the completion of the work described in **717.01**.

717.03 Basis of Payment

The Department will pay for Mobilization on a lump sum basis.

The Department will make partial payments for Mobilization with the first and second partial pay estimates paid on the Contract. Payment will be made at the rate of 50% of lump sum price for Mobilization on each of these partial pay estimates provided the amount bid for Mobilization does not exceed 5% of the total amount bid for the Contract. If the amount bid

for the item of Mobilization exceeds 5% of the total amount bid for the Contract, the Department will pay 2-1/2% of the total amount bid on each of the first partial payment estimates, and that portion exceeding 5% on the last partial pay estimate.

As an exception to the above, where the Work covered by the Contract is limited exclusively to the resurfacing of an existing pavement, including projects involving the milling off of a portion of the existing pavement prior to the laying down of new asphalt cement concrete layer(s), the Department will pay the entire lump sum price for the item of Mobilization, less the retainage provided for in Title 54-5-121, TCA, with the first partial pay estimate paid on the Contract, provided the amount bid for Mobilization does not exceed 5% of the total amount bid for the Contract. If the amount bid for the item of Mobilization exceeds 5% of the total amount bid for the Contract, the Department will pay 5% of the total amount bid for the Contract on the first partial pay estimate, and the portion exceeding 5% on the last partial pay estimate.

SECTION 722 – FIELD OFFICE

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DESCRIPTION

722.01 Description

This work consists of providing and maintaining an adequate, weatherproof field office for the exclusive use of the Engineer and Department staff during both the Contract period and for a maximum of 60 days thereafter.

GENERAL REQUIREMENTS

722.02 Location

Locate the field office or materials laboratory on a site that is both satisfactory to the Engineer and convenient to the Project site.

722.03 Minimum Spatial Requirements

Unless otherwise specified in the Special Provisions, the Engineer's field office shall meet the minimum floor area and headroom requirements specified Table 722.03-1. It shall contain a sufficient number of windows

to provide at least 27 square feet of natural light. Existing building structures meeting these minimum requirements are acceptable.

Table 722.03-1: Field Office Spatial Requirements

Building Type	Width (feet)	Length (feet)	Headroom (feet)	Windows Required
Type 1	10	30	8	6
Type 2	12	50	8	10

722.04 Other Requirements

Arrange for and comply with all necessary local and State regulatory permits and inspections, including all costs associated therewith.

Fully equip the Engineer's field office and have it ready for occupancy at least 2 days before the start of actual construction operations.

Protect the field office against fire, flooding, and theft throughout the 24 hours of every day the unit is in service. Assume responsibility for Department property housed in the field office that is lost due to theft, fire, or natural causes.

722.05 Outside Utilities

A. Electrical Power

Arrange for electrical service for the field office. The power supply shall be 115-volt, 60-cycle current of sufficient amperage to provide for heat, interior and exterior lighting, operating office equipment, and air conditioning.

B. Sanitary Sewer Outfall

Provide an adequate temporary outfall into either the municipal sanitary sewer system or an approved individual sewage disposal system. Dispose of sanitary wastes in accordance with the applicable requirements of the municipal regulations.

722.06 Interior Utility Services

A. Lighting

Furnish lighting fixtures as required to provide minimum illumination of 70 foot-candles in all areas.

B. Electrical Receptacles

Provide six duplex convenience electrical receptacles throughout the field office as directed by the Engineer. At least two of these receptacles shall be 20-amp capacity.

C. Heating and Air Conditioning

Provide heating and air conditioning equipment capable of maintaining a year round temperature between 70 °F and 78 °F.

D. Sanitary Facilities

Provide a water closet, lavatory, slop sink, vent fan, and a hot water heater having a minimum 5-gallon capacity.

E. Telephone, Answering Machine, and Facsimile Machine

Provide telephone service with an answering machine, a facsimile machine, and two incoming phone lines.

722.07 Doors and Windows

Provide doors of stock sizes and that have a key-in-knob lock of an approved manufacturer. Key all doors similarly. Provide operative windows except for picture windows. Operative windows shall be either double hung or casement type equipped with adequate locks. Provide all windows with either shades or Venetian blinds. Provide adequate screens for all window openings. Provide frosted glass for windows in sanitary areas.

722.08 Furnishings and Equipment

Provide the field office with the following:

A. Furnishings

1. Three office type desks, minimum top dimensions 32 x 60 inches, with two or more drawers on each side.

2. Three swivel desk chairs.

3. One work table, 30 inches high, with a minimum of 24 square feet of work area.

4. One drafting stool.

5. Two folding-type chairs.

6. One fire resistant drawer-type safe, legal size, with combination or key lock.

7. One four-drawer legal size metal filing cabinet equipped with lock.

8. Two two-drawer (14-1/2 x 16 inches) metal filing cabinets.

9. Two round wastebaskets.

10. One plan rack of an approved design to be equipped with ten rods.

B. Equipment

1. Two fully automatic electronic calculators with tape.

2. One office type copying machine.

3. One pencil sharpener.

4. One 5-pound CO2 fire extinguisher of approved manufacture for each 200 square feet of floor area.

5. One first-aid kit.

6. One electric sanitary water cooler with refrigerated storage compartment, with a continuous supply of paper cups.

7. Toilet paper holders, paper towel dispensers, and soap dispensers in the toilet rooms, with a continuous supply of each.

722.09 Concrete Cylinder Storage

Provide a storage shed/building for temporary storage of concrete acceptance cylinders. The storage facility shall be of sufficient size and construction to protect the concrete cylinders from the elements and damage. Obtain the Engineer's approval of the storage facility location. Department personnel will control access to the storage shed/building. Equip the storage shed with a concrete curing box or water curing tank with a heating/circulating system of sufficient size to properly cure all acceptance cylinders before transferring for final storage and testing. The curing box or curing tank and heater/circulator shall comply with AASHTO M 201, and proper curing of the cylinders shall be in accordance with AASHTO T 23.

722.10 Maintenance and Custodial Service

Provide the following maintenance and custodial services:

A. Maintenance

Perform all necessary repairs of damaged, defective, or vandalized parts of the field office and associated furnishings and equipment. Continue maintenance operations as long as the Engineer occupies the field office.

B. Custodial

1. Weekly trash removal.

2. A broom and dust pan or bi-monthly floor cleaning service.

3. Cleaning supplies or bi-monthly window and sanitary facility cleaning.

4. Replacement of supplies as required to maintain office equipment and sanitary facilities.

722.11 Project Sign

Equip the field office with a sign that identifies both the use of the structure and provides notice against trespassing.

COMPENSION

722.12 Basis of Pavement

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Field Office (Type __)	Lump Sum

Such payment is full compensation for providing all that is specified in this Section **722** for the duration of the Project.

SECTION 730 – TRAFFIC SIGNALS

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DESCRIPTION

730.01 Description of Work

This work consists of furnishing and installing all necessary materials and equipment to complete in-place traffic signal systems, modify existing systems, or both, all as shown on the Plans or the Standard or Special Details, and as specified in these Specifications. Unless otherwise shown on the Plans or specified in the Special Provisions, all materials shall be new.

Where existing systems are to be modified, incorporate the existing material into the revised system, salvage it, or abandon it as specified or as directed by the Engineer.

Furnish and install all incidental parts that are not shown on the Plans or specified herein, but that are necessary to complete the traffic signal or other electrical systems, or that are required for modifying existing systems, as though such parts were shown on the Plans or specified herein. Include the costs of such incidentals in bid price for other items. All systems shall be complete and in operation to the Engineer's satisfaction at the time of completion of the work.

GENERAL REQUIREMENTS

730.02 Regulations and Code

Ensure that all equipment provided conforms to NEMA Standards Publication, Traffic Control Systems, latest revision, or the Radio Manufacturers Association, whichever is applicable. In addition to the requirements of these Specifications, the Plans, and the Special Provisions,

all material and work shall conform to the requirements of the NEC; the Standards of ASTM, ANSI, ITE, and IMSA; the MUTCD; and other applicable local ordinances.

Wherever reference is made to the NEC, or the Standards mentioned above, consider the reference to mean the code or standard that is in effect on the date of advertising the bids or authorization for force account.

730.03 Submittal Data Requirements

Within 30 days after the issuance of the work order, submit to the Engineer, the Division of Materials and Tests, and the local entity (city or county engineer), one collated set of the manufacturer's descriptive literature and technical data that fully describes the types of signal equipment proposed for use. In the descriptive literature, identify the manufacturer and models and include sufficient information for the Engineer to determine if the equipment or material meets the requirements of the Plans and these Specifications. Include with these sets of submittal data a list of the materials submitted along with descriptive material for, but not limited to, the following items:

1. Controller
2. Cabinet and Exhaust Fan
3. Detectors
4. Signal Heads including Lamp Information and Mounting Hardware
5. Loop Wire and Loop Sealant
6. Shielded Detector Cable
7. Signal Cable
8. Cable for Span Wire, Guys, and similar features
9. Pull Boxes
10. Conduit
11. Coordination Equipment

Also include in the submittal sets detailed scale drawings of all non-standard or special equipment and of all proposed deviations from the Plans. Upon request, submit for approval sample articles of materials proposed for use. The Department will not be liable for any materials purchased, labor performed, or delay to the Work prior to such approval.

In addition to the above, submit to the Engineer a notarized letter certifying that all traffic signal materials listed in the submittal conform to the Plans

and Specifications along with a copy of a statement from the maintaining agency that the system is acceptable to the agency.

Submit six prints of "Design" or "Shop" drawings, indicating the proposed dimensions and material specification for each of the supports and mast arms involved, to the Division of Structures for approval purposes within 30 days after the work order is issued. The Department will review these drawings at the earliest possible date, and will return two prints marked "Approved for Fabrication," or "Returned for Revisions as Noted." Respond by taking appropriate action to ensure the earliest possible correction of these items so as not to delay the installation.

730.04 Mill Test Reports and Certification

Provide Mill Test Reports (MTR) or Certifications of Conformance to the Specifications for Materials and Design for all materials incorporated into the Work. Supply the following prior to acceptance of the structures:

1. MTRs for MAJOR structural items only, as identified in Table 730.04-1, shall include both physical and chemical descriptions of the material as supplied to the fabricator. When physical properties are altered during the fabrication, supplement the MTR covering chemical composition with certified test reports indicating the physical properties of this material after fabrication.

2. Certifications of Conformance to the Specifications for all remaining material not covered by MTR as identified in Table 730.04-1.

3. Certification that all welding was performed by operators qualified as follows: Steel welders to AWS and aluminum welders to ASME.

4. Certification of Conformance to the Specification for the Design of all components not completely dimensioned and detailed on the Standard Drawing.

Table 730.04-1: Required Mill Test Reports and Certifications

Component Materials	MTR	Certification
Tubes for arms and poles	X	
Base Castings	X	
Anchor Bolts	X	
Pole tops, misc. fittings, and hardware		X
Fabricated or cast-type arm connections		X
Galvanizing		X

730.05 Working Drawings

Provide within the controller cabinet and to the local maintaining agency an electrical schematic diagram of the cabinet and system wiring. Submit manufacturer's instructions for installation, maintenance, and operation of all equipment to the local maintaining agency and also place a copy within the controller cabinet. Place all such materials inside a plastic envelope mounted in the cabinet.

730.06 Guarantee

Guarantee the Traffic Signal System(s) installed under these Specifications, including all equipment, parts, and appurtenances in connection therewith, to the City or County and State against defective workmanship and materials for a period of not less than 1 year following the date the signal system is made operational, except in no case shall this guarantee expire prior to 3 months after the final acceptance of the Project. Upon completion of the Project, turn over to the government agency responsible for maintaining the signal installation all warranties or guarantees on equipment and materials that are offered by the manufacturers as normal trade practice and that have not expired.

730.07 Training

Provide to the maintaining agency a training session on the controller and associated cabinet equipment to be supplied on the Project. The training session shall last for a minimum 4 hours unless the maintaining agency determines a lesser time is adequate. Train the user in the complete operation and programming features of all controllers. Provide this training

prior to the acceptance of the Project at a facility agreed upon by the maintaining agency.

After the required training, certify to the Engineer that training has been completed.

This training requirement shall not apply if a training program meeting these criteria has been provided to the maintaining agency by this vendor and/or manufacturer on the equipment being bid within 18 months prior to the date of the invitation to bid. This requirement shall apply if the bidder is proposing new, upgraded, or modified equipment not covered in the previous training program.

MATERIALS AND INSTALLATION

730.08 Excavating and Backfilling

Perform excavation needed to install conduit, foundations, and other equipment, so as to cause the least possible damage to the streets, sidewalks, and other improvements. Excavate trenches no wider than necessary to properly install the electrical equipment and foundations. Do not begin excavating until immediately before installing conduit and other equipment. Place the material from the excavation where it will cause the least disruption and obstruction to vehicular and pedestrian traffic and the least interference with the surface drainage.

Backfill the excavations and compact to at least the density of the surrounding material. Remove all surplus excavation material and dispose of outside the highway right-of-way, in accordance with **203.07**, or as directed by the Engineer.

After backfilling, keep excavations well-filled, and maintain in a smooth and well-drained condition until permanent repairs can be made.

At the end of each day's work, and at all other times when construction operations are suspended, remove all equipment and other obstructions from that portion of the roadway used by public traffic, and park a minimum of 30 feet from the edge of pavement unless otherwise protected by guardrail, bridge rail, or barriers installed for other purposes.

Perform excavation in the street or highway so as to restrict no more than one traffic lane in either direction at any time. Do not obstruct traffic

during hours of peak flow unless otherwise approved by the Engineer. Incorporate construction signing in accordance with the MUTCD.

730.09 Removing and Replacing Improvements

Replace or reconstruct, with the same kind of materials as found on the Work, improvements, such as sidewalks, curbs, gutters, Portland cement concrete and asphalt concrete pavement, bituminous surfacing, base material, and all other improvements removed, broken, or damaged by the Contractor.

Before removing the sidewalk and pavement material, use an abrasive type saw to cut, to a minimum depth of 2 inches, the outline of all areas to be removed in Portland cement concrete sidewalks and in all pavements. Use any method satisfactory to the Engineer to cut the remainder of the required depth. Make cuts neat and true with no shatter outside the removal area.

Whenever a part of a square or slab of existing concrete sidewalk or driveway is broken or damaged, remove the entire square or slab and reconstruct the concrete as specified above.

Perform all work in accordance with these Specifications, or the applicable local ordinance, whichever is of a higher standard. Consider this removal and replacement work to be incidental to other items.

730.10 Foundations

Construct foundations for posts, standards, and cabinets of Class A Portland cement concrete.

Pour foundations for posts, standards, and pedestals after the post, standard, pedestal, or anchor bolts or reinforcing steel is in proper position. Form the exposed portions to present a neat appearance. Rest the bottom of concrete foundations on firm undisturbed ground.

Construct forms to be true to line and grade. Finish tops of footings for posts and standards, except special foundations, to curb or sidewalk grade or as ordered by the Engineer. Use rigid forms, securely braced in place. Place conduit ends and anchor bolts by means of a template until the concrete sets. Moisten both the forms and the ground that will be in contact with the concrete before placing concrete. Do not remove forms until the concrete has cured for at least 12 hours and hardened sufficiently to allow form removal without causing damage to the concrete.

Apply an ordinary surface finish to exposed surfaces of concrete. Wherever the edge of a concrete foundation or sidewalk section is within 18 inches of any existing concrete improvement, extend the sidewalk section to meet the existing improvement.

Where obstructions prevent the construction of planned foundations, construct a foundation satisfactory to the Engineer.

730.11 Anchor Bolts

Furnish, with anchor-base type poles, anchor bolts meeting the requirements of ASTM F1554, Grade 55 or other high strength steel anchor bolts having a minimum yield strength of 55,000 pounds per square inch and a minimum ultimate strength of 90,000 pounds per square inch. Fit each anchor bolt with two heavy hex nuts. Hot-dip galvanize all nuts and not less than 10 inches of the threaded ends of anchor bolts according to ASTM A153. The anchor bolts shall be capable of resisting at yield strength stress the bending moment of the shaft at its yield strength stress.

Set standards, posts, and pedestals plumb by adjusting the nuts before the foundation is finished to final grade. Do not use shims or similar devices for plumbing or raking. After plumbing or raking has been completed, cut off anchor bolts 1/4 inch above the top nut, and paint the exposed surface with rust protective paint.

Furnish all anchor bolts and nuts required for relocating existing standards and posts.

730.12 Pull Boxes

Construct and install pull boxes as shown on the Plans and the Standard Drawings or as directed by the Engineer. Additional pull boxes may be required where conduit runs are more than 150 feet long. Install pull boxes wherever practicable out of the line of traffic. Set covers level with the pavement, or with the curb or sidewalk grade, or with the surrounding ground as required.

Place electrical conductors within pull boxes so as to be clear of the metal frame and cover.

Rest the bottom of the pull box firmly on a bed of crushed stone with a minimum depth of 12 inches below the bottom, and extending 6 inches

beyond the outside edge of the pull box, unless otherwise directed by the Engineer.

A. Concrete Pull Boxes

Construct concrete pull boxes of a mixture of one part cement, two parts sand, and four parts gravel or 1-inch crushed stone with reinforcement placed as shown on the Standard Drawings. Reinforcement shall consist of welded wire reinforcement, 4 x 4 inches - No. 4/4 at 85 pounds per 100 square feet, meeting the requirements of **907.03**. Pull boxes may be poured in place or precast.

Install a cast iron frame and cover of the dimensions shown on the Drawings in each pull box. Provide castings of Class 30, meeting the requirements of **908.07**. The covers shall have a roughened top surface of 1/8 inch in relief. Provide notches for removing the cover. Inscribe the words "TRAFFIC SIGNALS" on top of the covers with letters 1-1/2 inches high and 1/8 inch in relief as shown on the Drawings.

The frame shall have a minimum weight of 42 pounds. The cover shall be of the "Extra Heavy" type with a minimum weight of 54 pounds.

B. Reinforced Plastic or Epoxy Mortar Pull Boxes

Ensure that pull boxes composed of reinforced plastic or epoxy mortar are designed and tested to temperatures of -50 °F and meet the requirements of the following: ASTM D543, ASTM D570, ASTM D790, and ASTM D635, and are based on a 30,000-pound single axle load over a 10 x 20 inch area. Inscribe the words "Traffic Signals" on top of the covers.

730.13 Transformer Base

Fabricate the transformer base from steel plate and sheet, and design it to harmonize with the shaft. Provide each transformer base with:

1. One 7-1/2 x 9 inch minimum handhole, with a cover secured with stainless steel fastening screws;

2. Four galvanized steel bearing plates to fasten the base to the anchor bolts;

3. Four galvanized steel bolts, nuts, and washers to fasten base and standard; and

4. One 1/2-inch, 13 UNC grounding nut welded to the inside of the base opposite the handhole opening.

Ensure that the strength of the transformer base is comparable with that of the shaft.

When a transformer base is required, no handhole will be required in the shaft.

730.14 Conduit

Furnish and install plastic and steel conduit in accordance with these Specifications and close conformity with the lines shown on the Plans or as established by the Engineer.

Threads shall be clean cut, straight, and true and of sufficient length to allow proper coupling. Do not use long running threads on any part of the Work. Protect threads in transit and during installation, and provide conduit with proper supports and protection during construction to prevent damage. Properly thread, ream, and cap all ends of pipe installed for future connections to prevent water and foreign matter from entering the conduit system. Provide threaded ends with approved conduit bushings.

Signal conduit shall be 2 inches in diameter, and detector conduit 1 inches in diameter, unless otherwise specified or directed. Conduit for service connections shall be 1-1/4 inches in diameter. Do not use conduits smaller than 1 inch in diameter unless otherwise specified, except grounding conductors at service points shall be enclosed in 1/2-inch diameter conduit. The Contractor may, at no additional cost to the Department, use larger size conduit, in which case it shall be for the entire length of the run with no reducing couplings allowed.

A. Materials

Provide conduits and fittings as follows:

1. Steel Conduit

a. Rigid conduit and fittings shall be heavy-wall, hot dipped galvanized steel conforming to Federal Specification WW-C-581-d(3) and ANSI C80.1. It shall be galvanized inside and out and shall meet the requirements of ASTM A53. Each length shall bear the label of Underwriters Laboratories, Inc.

b. Flexible conduit shall be galvanized flexible steel meeting Federal Specification WW-C-581-d(3), ANSI C80.1 and UL Standard 6 with a minimum 40-mil thickness of polyvinyl chloride (PVC) coating conforming to ASTM D746.

2. Plastic Conduit. For plastic conduit, provide high impact PVC, Schedule 40.

B. Installation

All bends shall be in strict compliance with the NEC.

Lay conduits to a depth of 6 inches below subgrade but not less than 24 inches below pavement grade except when approved by the Engineer; conduit may be laid at a depth of not less than 24 inches below top of curb when placed in back of the curb. Place conduit runs for detectors parallel to existing or proposed curbs and not more than 18 inches behind the curb face unless other specified. Place steel conduit or Schedule 80 PVC conduit under existing pavements by approved jacking or drilling methods. Do not disturb pavements without the Engineer's approval. Where trenching is allowed in a traffic bearing area, use PVC conduit (Schedule 40) encased in concrete.

After completing the installation of the conduit, test all conduits installed under the Contract with a mandrel having a diameter 1/4-inch smaller than the conduit and a length of 2 inches. Repair, to the Engineer's satisfaction, all conduits that will not allow passage of the mandrel; if repairs cannot be accomplished, remove and replace the conduit at no additional cost to the Department. After the mandrel test, scour all conduits with a stiff wire brush slightly larger in diameter than the conduit. Clear all conduits in the Engineer's presence.

Extend conduits terminating in anchor base standards and pedestals approximately 2 inches above the foundation and slope them toward the hand-hole opening. Conduits shall enter concrete pull boxes from the bottom and shall terminate not less than 2 inches nor more than 4 inches above the bottom of the box and near the box walls to leave the major portion of the box clear.

Clean existing underground conduit to be incorporated into a new system by blowing with compressed air, or by other means approved by the Engineer.

730.15 Conductors

Traffic Control Conductors shall be rated at 600 volts. Run all conductors, except loop conductors and cables run along messengers, in conduit, except where run inside poles. Where signal conductors are run in lighting standards containing high voltage street lighting conductors, encase the signal conductors in flexible or rigid metal conduit. Where telephone circuits are introduced into controller foundations, encase the telephone conductors in flexible metal conduit and in conformance with the NEC.

Conductors for traffic loops shall be continuous AWG No. 14 XLP stranded wire to the detector terminals or spliced with shielded detector cable within a pull box, conduit, or pole base.

Detector cable shall be two conductor twisted pair shielded AWG No. 14 stranded meeting IMSA Specification No. 19-2.

730.16 Cable

All signal cable shall conform to applicable IMSA Specification No. 19 or 20. Use stranded cable color coded AWG No. 14 for all signal and accessory circuits. Retain the same color identification for the entire length of a circuit run.

730.17 Wiring

1. Terminate all wiring to screw terminals using lugs.

2. Make all splices with solderless connectors, and insulate splices with weatherproof tape applied to a thickness equal to the original insulation.

3. Attach cables to messenger with non-corrosive lashing rods or stainless steel wire lashings.

4. All wiring within enclosed cabinets shall be neatly formed and harnessed and shall have sufficient length for access and servicing.

730.18 Service Connection

Coordinate service connection details and metering with the local utility as directed by the Engineer and in conformance with the City and County requirements. Obtain the necessary service for each installation.

730.19 Sealant

Provide sealant material selected from the Qualified Products List maintained by the Department's Material and Test Division for sealing saw-cuts. The sealant material shall resist the upward movement of loop and lead-in and shall exhibit stable dielectric characteristics, including a low permitivity and high dielectric strength. It shall bond to the roadway paving material, preventing entry of moisture, and shall remain flexible without melting through the anticipated temperature and weather conditions.

730.20 Strand Cable

Span cable for suspending signal heads between pole supports shall be 7-strand, Class A, copper-covered steel wire strand or greater, meeting the requirements of ASTM A460, with a minimum breaking strength as noted on the Plans. An acceptable alternate is 7-strand steel wire with a Class A zinc coating meeting the requirements of ASTM A475, with a minimum breaking strength as shown on the Plans.

Strand cable for messenger wire (other than span wire as specified above) and pole guy cable use shall be of the diameter(s) shown on the Plans and shall meet the requirements of ASTM A475 for zinc-coated steel wire strand, 7-strand Siemens-Martin Grade with a Class A zinc coating or greater.

A Figure 8 cable combining the messenger cable and conductor cable in an insulated jacket is an acceptable alternate to conductor cable lashed to a messenger cable.

730.21 Bonding and Grounding

Make metallic cable sheaths, conduit, transformer bases, anchor bolts, and metal poles and pedestals mechanically and electrically secure to form a continuous system, and ensure they are effectively grounded. Bonding and grounding jumpers shall be copper wire or copper strap of not less than the same cross-sectional area as No. 6 AWG.

Furnish and install a ground electrode at each service point. Ground electrodes shall be one-piece lengths of copperweld ground rod not less than 8 feet in length and 1/2 inch in diameter, installed in accordance with the NEC. Ground the conduit and neutral as required under the NEC, except that grounding conductors shall be No. 6 AWG or approved equal, as a minimum. Enclose exposed ground conductors in 1/2-inch diameter conduit, and bond to the electrode with a copperweld ground clamp.

730.22 Field Test

Prior to completing the work, conduct the following tests on all traffic signal and lighting circuits in the Engineer's presence:

1. Test for ground in circuit.

2. Conduct a megger test on each circuit between the circuit and ground. The insulation resistance shall be not less than the values specified in Section 119 of the NEC.

3. Conduct a functional test to demonstrate that each part of the system functions as specified or intended herein.

4. Test all detector loops and leads before and after they are sealed in the pavement to ensure there are no shorts to ground in the system and to ensure that the loop plus lead-in inductance is within the operating range of the detector.

Replace or repair, in a manner approved by the Engineer, all faults in material or in the installation revealed by these tests. Repeat the applicable testing until no fault appears.

730.23 Inspection

After completion of the installation and before final acceptance of the Project, conduct a full operational check of the system under actual traffic conditions in the presence of the Engineer. The operational check shall cover a minimum time period of 30 calendar days. During this period, perform all necessary adjustments and replace all malfunctioning parts of the equipment required to place the system in an acceptable operational condition at no additional cost to the Department. Perform all work and furnish all materials required under these Specifications subject to the direct supervision, inspection, and approval of the Engineer. Provide the Engineer and authorized representatives free access to the work, and to all plants, yards, shops, mills, and factories where, or in which, articles or materials to be used or furnished in connection with such work are being prepared, fabricated, or manufactured. Provide full and sufficient information to determine that the performance of the work, the character of materials, and the quality of workmanship and materials meets the intent of these Specifications.

Only perform work in the presence of the Engineer or the Inspector appointed by the Engineer, unless permission to do otherwise has first been obtained. The Engineer may reject any work that is performed or constructed in the absence of the Engineer or Inspector, without such permission having been granted, either expressly or by implication.

The inspection of the work shall not relieve the Contractor of its obligation to properly fulfill the Contract as specified. If the Engineer finds a part of the work, or the materials used in the work, to be defective or unsuitable at any time prior to final acceptance, repair or replace such defective or unsuitable work or material.

Request the presence of an Engineer or Inspector in connection with the work under these Specifications at least 24 hours before such services will be required.

SIGNAL HEADS

730.24 Signal Heads

Each vehicle signal head shall:

1. Be of the adjustable, colored lens, vertical type with the number and type of lights detailed as specified herein and as shown on the Plans;

2. Provide a light indicator in one direction only;

3. Be capable of adjustment (without attachments) through 360 degrees about a vertical axis; and

4. Be mounted as shown on the Plans or as directed by the Engineer.

Arrange the lenses in the signal faces in accordance with Section 4B-9 of the MUTCD. All lenses shall be glass. All circular indications shall use 12-inch lenses unless otherwise shown on the Plans. All arrow indications shall use 12-inch lenses. All new vehicle signal heads installed at any one intersection shall be of the same style and from the same manufacturer. Apply one or more coats of primer to all signal heads, signal head mountings, and outside of hoods, followed by two coats of high quality synthetic resin enamel of Traffic Signal Yellow meeting or exceeding Federal Specifications TT-C-595 Gloss Yellow.

Apply one or more coats of primer to louvers as specified, signal hood interiors, and back plates, followed by two coats of Lusterless Black Enamel meeting or exceeding Master Painters Institute (MPI) Reference 94. Examine all factory enameled equipment and materials for damaged paint after installation, and repair such damaged surfaces to the Engineer's satisfaction. Factory applied enamel finish in good condition and of appropriate color will be acceptable.

Suspensions for span wire mounting of multi-faced signal heads and signal head clusters (such as a 5-section signal head) shall include an approved swivel type balance adjuster for proper vertical alignment.

Fabricate signal heads from die-cast bodies. Sand castings will not be acceptable.

Ensure that all signal heads meet the minimum Contract requirements for adjustable face vehicle traffic control signal heads.

In addition to these requirements, comply with the following:

A. Optical Units

Signal lamps for 8-inch lenses shall be clear, 595 rated initial lumen output, with a minimum life of 6,000 hours. Signal lamps for 12-inch lenses shall be clear, 1750 rated initial lumen output, with a minimum life of 6,000 hours.

B. Signal Head Mounting and Mounting Brackets

Furnish signal heads that either have integral serrations or are equipped with positive lock rings and fittings designed to prevent heads from turning due to external forces. Lock ring and connecting fittings shall have serrated contacts. Provide signals with water-tight fittings using neoprene washers.

Support bracket-mounted signal heads, as shown on the Plans, by mounting brackets consisting of assemblies of 1-1/2 inch standard pipe size. Ensure that all members are either plumb or level, symmetrically arranged, and securely assembled. Conceal all conductors within poles and mounting assembly. Secure each slip fitter to the pole.

C. Directional Louvers

Where shown on the Plans, furnish and install louvers in the hoods of the signal head sections designated.

Directional louvers shall have a snug fit in the signal hoods. Construct the outside cylinder and vanes from a non-ferrous metal or galvanized sheet steel. Paint louvers with two coats of black enamel as specified in **730.24.F**.

D. Back Plates

Where shown on the Plans, furnish and attach back plates to the signal heads. All back plates shall be louvered and constructed of 3,003, half-hard, 0.051-inch minimum thickness aluminum sheet. Other materials such as plastic or fiberglass may be used where approved. In fabricating back plates, bend back the inside vertical edges, adjacent to the signal head, to form mounting brackets for attaching to the signal. Form back plates in two or more sections and bolt together, thus allowing for installation after signal heads are in place. Back plates shall have a dull black appearance.

E. Wiring

Signal head leads shall be No. 18 AWG stranded with 221 °F thermoplastic insulation. Wire a separate white (common) lead to each socket shell; and wire a colored lead, corresponding to the color code shown on the Plans, to each socket terminal. Provide leads of sufficient length to allow connection to the terminal block specified. Provide each complete signal head with a minimum 4-point terminal block, properly mounted in a signal section. Stud type terminal blocks shall have not less than 1/4-inch edge clearance to any portion of the stud. Exterior wiring shall have a 360-degree drip loop in advance of entering the head.

F. Pedestrian Signals

When shown on the Plans, provide pedestrian signals conforming to the following:

1. Pedestrian indications should attract the attention of and be readable to the pedestrian both day and night and at all distances from 10 feet to the full width of the area to be crossed.

2. All pedestrian indications shall be rectangular in shape and shall consist of the lettered messages WALK and DON'T WALK. For the purposes of these Specifications, interpret the messages WALK and DON'T WALK to be equivalent to the international symbols of a “Walking Figure” and “Upraised Hand,” respectively.

3. When illuminated, the WALK indication shall be lunar white meeting ITE standards, with an opaque material obscuring all but the letters.

4. When illuminated, the DON'T WALK indication shall be Portland Orange meeting ITE standards, with an opaque material obscuring all but the letters.

5. When not illuminated, the WALK and DON'T WALK messages shall not be distinguishable by pedestrians at the far end of the crosswalk they control.

6. The letters shall be at least 3 inches high for crossing where the distance from the near curb to the pedestrian signal indication is 60 feet or less. For distances over 60 feet, the letters shall be at least 4-1/2 inches high.

7. Design and construct the light source so that in case of an electrical or mechanical failure of the word DON'T, the word WALK of the DON'T WALK message will also remain dark.

Provide each section with a visor encompassing the top and sides of the signal face of a size and shape adequate to shield the lens from external light sources. Provide lamps of the 69-watt traffic signal type.

The housing door, door latch, and hinges shall be of aluminum, or approved equal. Hinge pins shall be stainless steel. Provide the door with a neoprene gasket capable of making a weather resistant, dust-proof seal when closed.

All pedestrian signal heads, mountings, outside of hoods, and pedestrian push button housings shall have one or more coats of primer followed by two coats of high quality synthetic resin enamel of Traffic Signal Yellow, meeting or exceeding Federal Specifications TT-C-595 Gloss Yellow. The interior of signal hoods shall have one or more coats of primer followed by two coats of Lusterless Black Enamel meeting or exceeding MPI Reference 94. Examine all factory enameled equipment and materials for damaged paint after installation, and repaint such damaged surfaces to the Engineer's satisfaction. Factory applied enamel finish in good condition and of appropriate color will be acceptable.

G. Signal Head Installation

Install signal heads with the faces completely covered until the entire installation is ready for operation.

CONTROLLERS – GENERAL

730.25 Controllers

A controller shall consist of the complete electrical mechanism for controlling the operations of traffic control signals, including the timing mechanism and necessary auxiliary equipment, mounted in a cabinet.

A. Interval Sequence

The color sequence of signal indications shall be green, yellow, and red. Overlaps, such as green and yellow indications showing at the same time, will not be permitted. During any interval there shall be no visual flicker of signal indications. Under no conditions shall controllers allow conflicting green signal indications to be displayed.

B. Flashing Operations

Equip controllers to allow any combination of flashing red or yellow lights. However, set the flashing operation for flashing yellow lights on the main street or highway unless otherwise specified in the Special Provisions, shown on the Plans, or directed by the Engineer. The flashing mechanism shall produce between 50 and 60 flashes per minute through two 120-volt, 15-ampere circuits. One illuminated period at each flash shall not be less than 1/2 and not more than 2/3 of the total cycle.

Pedestrian signals shall be dark during flashing operations. During normal operation, pedestrian signals shall flash DON'T WALK during the pedestrian clearance interval.

Use two circuit solid state flashers unless otherwise specified.

C. Wiring Diagrams

Submit a schematic wiring diagram of the controllers and auxiliary equipment at the time the controllers are delivered, or prior to ordering if requested by the Engineer. This diagram shall show in detail all circuits and parts. Identify such parts on the diagram by name or number and in such a manner as to be readily interpreted.

D. Operating Line Voltage

Provide equipment designed to operate from a 120-volt, 60-cycle AC supply. Operation shall be satisfactory at voltages from 105 to 130. All operating voltages into and out of the controller shall be NEMA level DC voltages, except for AC power (connector A, pin p and U).

E. Lightning Protectors and Interference Suppressors

Furnish ample lightning protectors to provide effective defense against high transient voltages caused by lightning discharges or other sources. Furnish each controller cabinet with the following surge protection devices:

1. Provide main power suppressor, for all but flasher or remote detector cabinets, having the following characteristics:

a.	Peak Surge Current:	20,000 amperes
b.	Clamp Voltage:	250 volts
c.	Response Time:	Voltage NEVER exceeds 250 volts
d.	Continuous Current:	10 amperes at 120 volts AC

2. For controller flasher, flashing beacon, and remote detector cabinets, provide a power protector having the following characteristics:

a.	Peak Current	15,000 amperes
b.	Power Dissipation	15 watts
c.	Peak Voltage	212 volts

3. Provide loop detector input terminals with the following:

a.	Peak Surge Current	400 amps Differential Mode 1,000 amps Common Mode
b.	Response Time	40 nanoseconds
c.	Input Capacitance	35 picofarads typical
d.	Clamp Voltage	30 volts max (either mode)

4. Provide auxiliary relays and fan with a resistor/capacitor circuit to suppress generated noise.

5. Provide an RF Filter in controller cabinets capable of filtering of RF noise over the range of 60 hertz through 20 Megahertz. The RF filter may be incorporated as part of the Main Power Suppressor.

F. Controller Cabinets

House the controller in a rigid, weatherproof cabinet, constructed, finished, and equipped as follows, and as shown on the Standard Details:

1. Material. Provide weather-tight cabinets fabricated from aluminum sheet or cast aluminum alloy with a minimum 0.125-inch thickness. Painting of cabinets is only required if the final finish presents an unsightly appearance.

2. Doors. Type III, IV, and V cabinets shall have a hinged front opening door that shall include substantially the full area of the front of the cabinet. Equip the door with a positive hold fast device to secure the door in at least two open positions: one position at approximately 90 degrees and the other at 120 degrees or more. The holdfast device shall be easily secured and released without the use of tools. Equip doors for Type II, III, IV, and V cabinets with a switch compartment, and provide the manual switches, specified in **730.25.F.6.j**, with a hinged front opening auxiliary door. Each door shall have a gasket to provide a weatherproof seal when closed.

Provide the main door with a No. 2 pin-tumbler cylinder lock, and the auxiliary door with a standard police sub-treasury lock. Provide four keys for each lock.

3. Cabinet Mounting. Mount cabinets as shown on the Plans or Standard Details.

4. Ventilation. Unless otherwise specified, provide ventilation as follows:

a. On all cabinets housing controllers, mount a screened, rain-tight vent, 1-1/2 inches in diameter or larger, on the cabinet top.

b. Provide screened or filtered inlet ventilation openings, equal to or greater in area than top vents, located in the bottom or lower back side of Type I and II cabinets or around the lower 8 inches portion of Type III cabinets.

c. Construct the vents so as to project within the cabinet no more than necessary to provide for lock nuts and gaskets to retain the vent.

d. Locate vents so as to not interfere with the mounting of controller equipment.

5. Cabinets with Exhaust Fans. Exhaust fans shall consist of an electric fan with ball or roller bearings and a capacity of at least 100 cubic feet per minute. Mount the fan in a rain-tight housing attached to the top of the controller cabinet.

The fan shall be controlled by a thermostat having a temperature differential between turn-on and turn-off of 15 °F (-0, +5 °F), adjustable for turn-on through a minimum calibrated range of from 100 °F to 150 °F.

Whenever a fan is to be installed, provide the air inlet filter and filter holder shown in the Standard Details, or approved equal. Internally seal other air inlets. Provide exhaust fans in all cabinets that house controllers, with the exception of flasher controllers.

6. Auxiliary Equipment. With the exception of cabinets used in special applications (Type I and II), provide all cabinets with the following:

a. Substantial shelves or brackets to support controller and auxiliary equipment.

b. Panel for terminals arranged for adequate electrical clearance.

c. Control panel assembly consisting of:

1. Power supply connections made to a 30-ampere circuit breaker mounted on the cabinet separate from the signal terminal panel. The circuit breaker shall be a magnetic trip type, having an interrupting capacity of at least 2,000 amperes at 125 volts AC. The circuit shall trip between 101% and 125% of rated load, with an inverse time delay characteristic provided. Instantaneous tripping shall occur at ten

times the nominal rating. All controllers shall be internally fused.

2. Service line surge protection.

3. Electrical service termination point sized to accept No. 4 AWG copper wire.

4. Ground fault receptacle.

5. Porcelain lamp receptacle to accept a standard traffic signal lamp.

6. Circuit breakers for:

   (a) Main power input to provide all power associated with normal operation.
   (b) Flasher power input to provide all power associated with flash operation.
   (c) Service power to provide power for the lamp and duplex receptacle.

7. Copper ground bus (minimum of 12 positions).

d. Flasher mechanism independent of controller.

e. General purpose relays, where required to perform specified functions.

f. Type II, III, IV, and V cabinets, when specified as housing for traffic actuated controllers, with two or more insulated terminal blocks mounted within the housing, one or more for terminating each field wire.

g. A minimum of 12 available bare ground positions tied to AC Common Return.

h. Earth (driven) ground tie point to terminate a single No. 4 AWG copper ground.

i. A tie point to tie all ground systems within the cabinet to a single reference point. All grounds (AC - return,

Chassis, and Logic Ground) must be referenced to a single ground point at the electric service.

j. A panel behind the auxiliary door shall contain the following switches:

1. A main power switch, which shall be wired to remove all cabinet power when in the Off position

2. An Automatic Flash switch, which shall be wired as follows:

(a) The Flash position shall cause the cabinet to provide Flash Operation. The controller shall continue to operate, and Stop Time shall be applied to the controller.

(b) Upon return from Flashing to Automatic, the controller shall initialize in the Start-Up Display condition. This display, unless noted otherwise, shall be Green for the Artery phase(s).

3. A panel mounted inside the main door shall contain the following switches:

(a) A technician Stop-Time switch to apply Stop Time to each controller ring.

(b) An Interval Advance switch, enabled only by the Stop Time switch, to be momentary pushbutton switch to apply Interval advance to the timer.

(c) A Signal On-Off switch, which shall remove the AC power applied to the signal heads for normal operation while the controller continues to operate.

(d) Individual phase vehicle and pedestrian detector test switches to be miniature toggle of the On-Off Momentary type to place:

i. No Call - Call provided by detectors

ii. Locked detector call
iii. Momentary detector call

Insulate or shield switch terminals on back of main cabinet door so that no live parts are exposed.

Leads from the terminal block to the auxiliary door switches shall be no less than No. 18 AWG stranded, with TW plasticized polyvinyl chloride or nylon insulation enclosed in an insulating loom, and shall be of sufficient length to allow full opening of the main cabinet door.

k. Wire the cabinet according to the following:

1. Wire four phase controllers for four vehicle phases, two pedestrian phases, and two overlaps. Include eight NEMA load switch bases per cabinet.

2. Wire eight phase controllers for eight vehicle movements, four pedestrian phases, and four overlaps. Provide twelve NEMA load switch bases.

l. Supply all cabinets with a Signal Conflict Monitor (SCM) that meets the NEMA standards. The SCM for all controller cabinets with three or more phases shall be the 12-channel type, and shall have the following features:

1. Liquid Crystal Display to show all data in English language format.

2. Capability to monitor all Green/Yellow/Red/Walk field display outputs.

3. Capability to monitor the Controller 24 VDC output and be user programmable to have this monitor function Latch On.

4. Capability to monitor the Controller Voltage Monitor output, and be user programmable to have this monitor function Latch On.

5. Per Channel monitoring of Phase Yellow Clearance Interval, and shall cause flash operation if Yellow Clearance is less than the SCM programmed time (2.7 - 9 seconds).

6. Front panel mounted over-current protection (no internally mounted fuses are acceptable).

7. Front panel mounted reset switch.

8. Fault logging features - the SCM shall log all faults as to the:

   (a) Date of fault
   (b) Time of fault
   (c) Fault condition
   (d) Power failure

   and store these fault conditions in no-volatile memory for user retrieval. The monitor shall be able to store at least ten such faults. The internal time clock shall automatically adjust for Daylight Savings Time changes. There shall be a keyboard method for the user to display and clear the stored event log.

9. There shall be an RS-232 port on the SCM to allow the user to print all data stored in the SCM. The printer shall interface with the SCM via a standard RS-232 cable. Printer to be supplied by others.

10. The SCM shall detect the following conditions and place the cabinet in the flash mode by De-energizing the Flash Transfer Relays:

    (a) Absence of an active AC input on a channel
    (b) Green/Yellow both active on a channel
    (c) Yellow/Red both active on a channel
    (d) Green/Red both active on a channel
    (e) Green/Green active on conflicting channels
    (f) Green/Yellow active on conflicting channels
    (g) Green/Walk active on conflicting channels
    (h) Low 24 VDC sample
    (i) Controller Voltage Monitor active

(j) Clearance time less than programmed

11. On circuits where all field outputs are not used (such as left-turn phases), unused circuits shall be terminated at a load resistor and the monitor plus features shall function.

12. No functional field display shall be permitted unless monitored by the SCM.

13. Terminate the SCM sampling inputs at the closest tie point to the field termination.

7. Enhanced Operational Features. When shown on the Plans, or specified in the Special Provisions, supply certain enhanced operational features of controllers. When required, these inputs and outputs shall be accessed to the controller by a dedicated fourth (or "D" Connector). Provide a connector of a type as determined by the manufacturer, and that meets the following requirements:

a. This connector shall not be mateable to any other connector in the cabinet.

b. All operating voltages in this connector shall be NEMA DC level voltages.

c. No special operating features shall enter or exit the controller on any NEMA pin designated as "Spare" or "Future."

d. When the "D" connector is not connected to the controller, the cabinet facility shall operate as a standard NEMA cabinet facility with no operational loss of standard NEMA features.

e. If the "D" connector is used as the input source for Pre-Emption operation, wire the cabinet facility so that the cabinet facility will NOT perform any operation other than FLASH unless the "D" connector is terminated at the correct termination point and all cabinet features including Pre-Emption are operational.

TRAFFIC ACTUATED CONTROLLERS

730.26 Traffic Actuated Controllers

The controller mechanism shall meet or exceed the current NEMA Traffic Signal Systems Standard. Provide Standard A, B, and C Connectors. Submit private laboratory certification that the proposed unit is in complete compliance with the NEMA standards in effect at the time of the advertisement for bids.

The controller shall have all timing values entered via a front panel mounted keyboard. This keyboard shall be an integral part of the controller unit.

Each controller shall have all operating timing parameters as specified in NEMA on a per phase basis, including all Volume/Density features. Each phase shall have a defeatable Last Car Passage feature wherein the last vehicle receiving the Phase Green shall receive at least one full Passage Time increment.

The controller shall have all of the following keyboard entered values or parameters:

1. Start on condition of the controller where the user can select via the keyboard the following:

    a. Phases to start in
    b. Phase display to be on
    c. Overlap display start-on condition
    d. Normal start-up display shall be mainstreet green phase(s), with concurrent overlaps green

2. Phase recall functions:

    a. Non-lock detector
    b. Lock detector call
    c. Minimum recall
    d. Maximum recall
    e. Pedestrian recall
    f. Non-actuated phase
    g. Phase not active, phase omitted
    h. Pedestrian phase omitted

3. All phase interval timing values except the Phase Yellow Clearance shall be as per NEMA. Each controller phase Yellow Clearance Interval is 3 seconds as a minimum.

The controller shall have a back-lit liquid crystal display for each ring of the controller to provide an English language menu for programming with displays for programming or reading all controller features. The dynamic displays for real-time operation shall be able to display the following values for each ring or phase(s) concurrently:

1. Per Phase Display:

    a. Phase Vehicle Call
    b. Phase Pedestrian Call
    c. Phase is Next In Service
    d. Phase is In Service
    e. Phase Pedestrian Intervals in Service

2. Per Ring Display:

    a. Ring Gapped Out
    b. Ring Maximum Green Termination
    c. Ring was Force Off Terminated
    d. Ring Maximum Green II in effect
    e. Ring Phase in Service Operating:

        i. Lock Call
        ii. Non-Lock Call
        iii. Minimum Recall
        iv. Maximum Recall
        v. Pedestrian Recall
        vi. Non-Actuated Mode

3. Per Ring Display of Timing Values (Real Time). The following values shall be selectively displayed and shall display the current value in a real time mode.

    a. Minimum Green Interval
    b. Passage Timer
    c. Pedestrian Interval Timing
    d. Maximum Green Timer
    e. Time Before Reduction Timer
    f. Time to Reduce Timer

It shall be possible to inspect and alter any currently programmed value while the controller is in operation without affecting the field operation. The controller shall continue to operate the intersection as values are inspected or altered.

The controller shall store all operator entered data in EEPROM devices that require no battery to support value storage. No internal components of circuitry shall require battery support.

The timer shall have a front-panel mounted RS-232 connector to allow the user to print a hard copy of all programmed data to a standard serial printer. The printer shall use a standard RS-232 connecting cable. Printer to be supplied by others.

730.27 Auxiliary Equipment for Traffic Actuated Controllers

Furnish and install the following auxiliary equipment in each cabinet for traffic actuated controllers.

A. Load Switches

Provide each cabinet complete, with the necessary number of NEMA load switches and Flash Transfer relays necessary to effect the specified signal sequence and phasing. Load switches shall:

1. Meet NEMA standards.

2. Have front-face mounted LED indicators to indicate the "On" condition of both the Input and Output circuits.

3. Use replaceable "cube" type circuitry or encapsulated discrete component construction. No unencapsulated discrete component construction are acceptable.

B. Time Clock Switches

Where shown on the Plans, provide time clock switches of solid state circuitry, continuous duty, with a 7-day cycle clock operating from the 120-volt AC service line. Provide switching for a minimum of one independent output and ensure the time of day selection is adjustable to within 1 minute of the desired time. Provide a battery backup system that can maintain time keeping and memory a minimum of 24 hours

after power interruption. Furnish an omitting device as an integral part of the time switch to allow the switching operation to be skipped for any preselected day or days of the week. The time clock shall automatically compensate for daylight savings time changes. When the time clock is supplied as an internal component of the controller, supply the clock feature to provide for the selection of Maximum Green II on time of day, day of week, week of year basis. Time clocks shall meet NEMA environmental specifications.

FLASHING SCHOOL SIGNALS

730.28 Flashing School Signals

When shown on the Plans, provide flashing school signals that conform to the following:

1. The signal shall produce two alternate flashing lights within the marginal limits of a school speed limit sign. Details of the sign construction shall be as shown on the Plans. Sign colors shall conform to the MUTCD and be constructed of materials complying with these specifications.

2. The two lenses shall be yellow in color and a minimum of 8 inches in diameter. Mount the lenses in the sign using a molded endless rubber gasket with the sign being mounted to the signal case. The reflector for the round lens shall be glass and firmly mounted between the lens assembly and the case so as to produce a weather-proof and water-tight optical unit.

3. Provide a two circuit type flasher unit to provide alternating equal on-off operation. The flashing mechanism shall produce between 50 and 60 flashes per minute through two 120-volt, 60-cycle AC, 15-ampere circuits. The flasher shall be of solid state construction.

4. Wire the unit for external circuits.

5. The signal shall be actuated by time switch meeting **730.27**. Locate the timing device in a remote mounted control cabinet.

6. Where an illuminated speed limit indication is shown on the Plans, the numeral message shall be illuminated in Portland Orange in a

rectangular lens and illuminated only during the period when the signal produces two alternately flashing amber lights.

DETECTORS

730.29 Detectors

Provide detectors, of the type shown on the Plans, to actuate signal phases of traffic actuated controllers. Provide ample lightning protection to provide effective defense against high transient voltages caused by lightning discharges or from other sources. The lightning protection unit must withstand repeated 400-ampere surges on a 9 x 20 microsecond waveform. Also, the unit must be a two-stage device capable of clamping a minimum of one hundred 300-ampere surges to 25 volts within 40 nanoseconds for surge applied across the two detector leads.

A. Inductive Loop Detectors

Loop amplifiers shall be of the single-channel, totally self-contained type, using a standard 10-pin MS connector (MS3102A-18P) and designed to operate within the NEMA environmental standards. All loop amplifiers shall be of the type to provide both "Extended" and "Delayed" outputs.

The loop detector amplifier shall be full automatic, requiring no adjustments to effect operational ability other than setting of the operating frequency and sensitivity. The amplifier shall:

1. Sense any legal motor vehicle traveling at speeds up to 65 miles per hour.

2. Have both a "Pulse" and "Presence" Output:

    a. Pulse output shall generate an output of 125 ±25 millisecond output for each vehicle entry.
    b. Presence output shall provide a continuous output for up to 60 minutes as long as a vehicle is within the detection zone.

3. Provide at least four user selectable sensitivity ranges.

4. Be supplied with at least three frequency ranges for crosstalk minimization.

5. Have a front-face mounted indicator to indicate active output of the internal relay. This indicator shall indicate the presence of:

    a. Normal Output
    b. Delayed Output
    c. Extended Output

6. Have a front-panel mounted "Reset" switch that when pressed shall cause the unit to completely re-tune itself.

7. Have Delayed or Extended timing features with the following ranges:

    a. Delayed output of 0 to 30 seconds in 1-second increments.
    b. Extended output of 0 to 10 seconds in 1/4-second increments.

8. Have internal diagnostics to determine the operational ability of the loop. These diagnostics shall determine if a loop is opened or shorted, and shall provide a visible indication of such condition. Additionally, if such a condition occurs, the amplifier unit shall default to a "constant" output.

9. Provide output by a mechanical relay, which shall be "off" to provide an output.

10. Have all delay functions wired to the associated plan phase green to inhibit that function during controller phase green.

11. Be able to operate with loop lead-in lengths of at least 2,000 feet.

Comply with the details of the detector loop installation as shown on the Plans or Standard Drawings.

B. Pedestrian Push Buttons

Where shown on the Plans, furnish and install pedestrian push buttons of substantial tamper-proof construction. They shall consist of a direct push type button and single momentary contact switch in a cast metal housing. Operating voltage for pedestrian push buttons shall not exceed 24 volts.

Provide a weatherproof assembly, constructed to prevent electrical shocks under any weather condition.

Where a pedestrian push button is attached to a pole, the housing shall be shaped to fit the curvature of the standard or post to which it is attached to provide a rigid installation.

Unless otherwise specified, install the push button and sign on the crosswalk side of the pole.

C. Magnetometer Detectors

Provide magnetometer detectors capable of being activated by a change in the magnetic field caused by the presence or passage of a vehicle within the lane of required detection at any speed from 0 to 80 miles per hour. The term "magnetometer detector" applies to a complete installation consisting of a sensing element or group of sensing elements installed in the roadway as shown on the Plans, lead-in cable, and a control unit with power supply installed in a traffic signal controller cabinet or special cabinet as shown on the Plans.

The sensing elements shall be no larger than 2 inches in diameter by 4 inches high and shall contain no moving parts or transistors.

The control unit shall be an electronic device capable of providing closure of an output circuit when a vehicle stands over or passes through the magnetic field of the sensing elements connected to the input circuitry of the control unit. The output shall be electrically insulated from the sensing element and the electronic circuitry.

Each detector shall operate from a 120-volt, 60 hertz, AC supply. Operation shall be satisfactory at voltages from 110 to 130. In addition, the unit shall not be affected by normal powerline transients or by powerline voltage variations of plus/minus 10%.

The control unit for the magnetometer detector shall be designed for (1) permanent presence, (2) pulse presence, (3) presence counting of vehicles, or combinations thereof.

The permanent presence control unit shall signal continually the presence of any vehicle until the vehicle leaves the area of detection, where upon the vehicle signal shall immediately drop.

The pulse presence control unit shall provide one x 30-millisecond, plus/minus 10%, pulse for every vehicle entering the area of detection.

The presence counting control unit signal shall provide separate detection of each distinct traffic lane.

Each control unit shall have solid state circuitry, except for the output relay. House each unit in a control box. Furnish each control unit with an integral power supply. Each control unit shall be designed to provide ease of maintenance. All electronic components shall be easily accessible.

Calibrate the control unit with tuning controls.

Each detector shall provide positive vehicle detection without readjustment from -20 °F to +160 °F.

Mount all controls, pilot lights, meters, fuse-holders, and connectors on the front panel of the control unit or the control power source assembly. Input power shall be fused.

When control unit and power supply components are mounted on insulating boards, printed circuit wiring may be used. Provide printed circuit boards designed to facilitate identification of components; provide either part identification markings or a pictorial diagram showing the physical location and identification of each component.

Place the sensing elements in holes cut in the roadway at the locations shown on the Plans. Make each hole large enough to accept a 2-inch diameter sensing element and to be 8 ± 2 inches deep. Make the holes vertical, regardless of the slope or grade of the pavement surface.

COORDINATION

730.30 Coordination

The following are the minimum design and operating requirements for all types of local coordinating units. The general design requirements apply to master coordinating units and secondary coordinating units; as a separate unit or internal to the controller; both dial electro-mechanical, and digital full solid state. Local coordinating units provided for an interconnected signal system shall be completely compatible with the master controller and all local controllers in that system.

Use the coordinating units described herein in conjunction with solid state traffic actuated signal controllers and traffic adjusted master controllers. The coordinators shall inhibit the external extension limit in the local controllers and provide external maximum control. Background cycle lengths, splits, system offsets, and other coordination functions as required shall be called in by a master controller or coordinator. These functions may also be called in by local or master override or time switches.

Furnish coordinating units capable of at least the following:

1. Three background time cycles.

2. Three splits per cycle.

3. Three offsets per cycle.

4. Multiple and adjustable permissive periods for yielding to non-coordinated phases.

5. Force off capability for all non-coordinated phases.

6. Capability of generating as a minimum cycle lengths of 50, 60, 70, 80, 90, 100, and 120 seconds.

7. Master intersection control and supervision of other coordinating units as required.

8. Free operation when called for by the system master, time switch, or manual override.

It shall be possible to set offset splits and all synchronization functions from the front of the coordinating unit, and to make these settings in at least 1% steps to any percentage of the associated cycle length.

Absence or conflict of offset or cycle information on the interconnect shall place the coordinating unit in cycle number 1 (average offset) or a preset standby cycle.

730.31 Time-Based Coordination Units

This Subsection covers traffic signal system time-based coordination units of solid state design. Time-based coordination units are used to control the timed relationship between intersections to maintain a system interconnect plan without the use of interconnect cable.

A. Background Cycle

Provide time-based coordination units with at least three independently programmable background cycles. The background cycles shall be in fixed increments, not exceeding 1 second.

B. Offsets

Provide time-based coordination units with at least three independently programmable offsets per background cycle.

C. Splits

Each split shall have at least six independently programmable force-off points, one for each non-coordinated phase. Provide two splits per background cycle.

D. Timing Requirements

Provide color- or function-coded time controls for programming the background cycle, offsets, force-off points, and permissive periods. Timing of all functions shall be digital, with an accuracy of ±100 milliseconds from the programmed value.

Ensure that the minimum timing ranges and maximum increments of adjustment for the various timing functions meet Table 730.31-1.

Table 730.31-1: Timing Requirements

Function	Minimum Timing Range	Maximum Increment of Adjustment
Background Cycle	30 to 255 seconds	1 second
Offset	0 to 255 seconds	1 second
Force-off Points and Permissive Periods	0 to 99% of cycle	1% of cycle

The clock circuit of time-based coordination units may use either the 60-hertz AC power source or a crystal oscillator as the timing reference. If a crystal oscillator is used as the timing reference, the frequency tolerance of the clock circuit shall be ±0.005%. The clock circuit of the time-based coordination unit shall allow for setting to the nearest second.

Provide the time-based coordination unit with a programmable feature that automatically changes from standard time to daylight savings time and vice versa.

E. Battery Power

Provide time-based coordination units with a battery to power the clock circuit and memory for a minimum of 100 hours when the 120 volt AC power source is disconnected.

F. Manual Override

Time-based coordination units shall be designed so that the programmed time of day function can be manually overridden to select a different function, such as cycle, offset, or splits.

G. Indicator Requirements

Time-based coordination units shall provide the following minimum indications:

1. Time of day (hours, minutes, and seconds)
2. Day of week or calendar date
3. Outputs controlled by day program

4. Cycle count - indicates time in background cycle
5. Day program in effect
6. Week program in effect
7. Battery status

H. Construction

Time based coordination units shall be a built-in component to the controller.

I. Data Transfer

Time based coordination units shall provide transferring of all programmed data from unit to unit by using a data transfer cable. Supply a cable with each unit.

TRAFFIC SIGNAL SUPPORTS

730.32 Cantilever Signal Supports

This Subsection applies to the manufacture of steel poles and mast arms for the support of traffic signals. The height of poles, shaft dimensions and wall thickness shall meet the design requirements and mounting height of traffic signals as set forth in these Specifications and shown on the Plans. The Plans indicate bracket arm lengths.

Furnish poles consisting of a straight or uniformly tapered shaft, cylindrical or octagonal in cross-section, having a base welded to the lower end and complete with anchor bolts. All castings shall be clean and smooth with all details well defined and true to pattern. Steel castings shall conform to ASTM A27, Grade 65-35. Gray iron castings shall conform to ASTM A126, Class A.

All mast arms shall be compatible with the poles in material, strength, shape, and size.

A. Anchor Base

Secure an anchor base of one-piece cast steel or steel plate of adequate strength, shape, and size to the lower end of the shaft. Place the base so as to telescope the shaft, and weld at the top and bottom faces with continuous fillet welds so that the welded connection develops the full

strength of the adjacent shaft section to resist bending action. Provide each base with a minimum of four holes to receive the anchor bolts. Provide cast steel bases with removable cast iron covers for anchor bolts and tapped holes for attaching covers with hex head cap screws.

Provide a welded frame handhole, 5 x 8 inches minimum and located 1 foot above the base. Weld a 1/2-inch 13 UNC grounding nut to the inside of the pole at a point readily accessible for wiring.

B. Shaft

Fabricate shafts from the best, hot-rolled basic open hearth steel. The shaft shall have only one longitudinal electrically welded joint and may have electrically welded intermediate transverse full penetration circumferential joints, at intervals of not less than 10 feet. The shaft shall be longitudinally cold-rolled to flatten the weld and increase the physical characteristics so that the metal will have a minimum yield strength of 48,000 pounds per square inch. Where transverse full penetration circumferential welds are used, the shaft fabricator shall furnish to the Engineer certification that: (1) all such welds have been radiographed and ultrasonically tested by an independent testing laboratory using a qualified Nondestructive Testing (NDT) technician and (2) the NDT equipment has been calibrated annually.

Fit the shaft with a removable pole cap, a J-hook wire support welded inside near the top, and a flange plate assembly to match that welded to the butt end of the mast arm.

C. Mast Arms

Provide mast arms fabricated and certified in the same manner as the upright shafts and that have the same physical characteristics.

The mast arms shall meet the design requirements necessary to support rigidly mounted traffic signals as shown on the Plans. All arms shall include a removable cap at the tip, grommeted wire outlets, and signal hanger assemblies of the type and number shown on the Plans, and a flange plate welded to the butt end to provide a rigid connection to the mast. The assembly shall be constructed so that all wiring can be concealed internally.

Connect mast arms to the upright pole at a height necessary to provide a minimum clearance of 16 feet 6 inches and a maximum clearance of

19 feet under the traffic signal heads. Install separate signal heads to provide the same clearance.

D. Finish

Galvanize steel poles, mast arms, and hardware in accordance with ASTM A123.

Galvanize all steel and cast iron components, hardware, and threaded fasteners, except anchor bolts, after fabrication in accordance with ASTM A123, or A153 or A385, as applicable.

730.33 Steel Strain Poles

Provide steel strain poles consisting of a uniformly tapered or equivalent upright shaft fitted with a removable pole top, J-hook wire support and 45-degree wire inlet near the top, a span wire clamp, a 5 x 8 inch handhole with reinforced frame and cover, bent anchor bolts, and all other accessories needed to make a complete installation. The pole and all of its component parts shall be designed to support tethered traffic signals of the type and number shown on the Plans, suspended from a span wire assembly. Fabricate and certify the poles as specified for the upright shafts in **730.32**.

Determine the shaft length required to meet field conditions and vertical clearances of signal heads over the roadway. The signal head clearance shall be a minimum of 16 feet 6 inches and a maximum of 19 feet. Fasten the span wire no closer than 1 foot 6 inches from the top of the pole.

Unless otherwise specified, provide all strain pole traffic signal supports with a one-piece anchor type base, fabricated from drop forged or cast steel of sufficient cross-section to fully develop the ultimate strength of the poles. Fasten the base to the pole with a welded connection that develops the full strength of the pole. Provide the base with a minimum of four holes of sufficient size to accommodate the proper size anchor bolts that are capable of resisting at yield strength stress, the bending moment of the shaft at its yield strength stress. Provide removable cast iron covers for the anchor bolts.

The shaft shall be fabricated from material providing a minimum yield strength of 48,000 pounds per square inch after fabrication.

Galvanize the steel poles and hardware in accordance with ASTM A123.

Galvanize all steel and cast iron components, hardware, and threaded fasteners, except anchor bolts, after fabrication in accordance with ASTM A123, or A153 or A385, as applicable.

730.34 Pedestal Support Signal Poles

Provide pedestal poles consisting of one upright pole with suitable base and other accessories or hardware as required to make a complete installation.

All poles shall be made of one continuous piece from top of base connection for the entire height of the pole. The cross-section shall be either cylindrical or octagonal and may or may not be uniformly tapered from butt to tip.

The cross-section at the tip shall have a 4-1/2 inch outside diameter.

A. Type "A" Pedestal (Aluminum)

Pedestals shall be of uniform octagonal or cylindrical cross-section of the tubular tapered type fabricated of one full length sheet.

Bases shall be octagonal or square in shape, of the ornamental type fabricated of cast material. Provide a handhole in each base.

Caps shall be of the nipple or tenon type mounting fabricated of cast material.

Furnish bases with four steel anchor bolts of sufficient size and length to securely anchor the base to the concrete footing. Weld the shaft to the cast metal base. Refer to the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals (current edition).

Type A pedestal shaft shall be fabricated from aluminum tubing 6063-T4 heat treated to T-6 temper after fabrication, and meeting ASTM B221.

Type A anchor base shall be made of sand-cast aluminum alloy 356-T6 meeting ASTM B26 - SF 70A-T5 specifications.

B. Type "B" Pedestal (Steel)

Pedestals shall be fabricated from a 4-1/2 inch (outside diameter) seamless steel pipe.

Bases shall be octagonal in shape of the ornamental type fabricated of cast or malleable iron and shall have minimum height of 12 inches. The top opening of the base shall be threaded to receive the shaft. Provide a handhole in each base.

Furnish bases with four steel anchor bolts of sufficient length to securely anchor the base to the concrete footing.

730.35 Wooden Pole Signal Supports

A. General

Provide wooden poles of the class and length shown on the Plans and that meet **917.11**. Set poles to the depth shown on the Plans, and fit them with all the necessary hardware to make the installation complete.

The signal head clearance shall be 16 feet 6 inches minimum and 19 feet maximum. Fasten the span wire at least 2 feet below the top of the pole.

B. Guying Components

Guy clamps shall be steel, 3-bolt type, 6 inches in length, and of the proper strand size to fit the wire used. The clamp bolts shall have upset shoulders fitting into the clamp plate. Substitution of the cable grip is subject to the Engineer's approval.

Attach guy wire to the pole with a 5/8-inch diameter x 12-inch length single strand angle-type eye bolt with 2 x 2 inch square cut washers, lock washer, and square nut.

Instead of the eye bolt specified above, an angle single strand eye of drop forged steel may be used, fastened on threaded end of span wire eye bolt.

Sidewalk guy fittings shall consist of 2-inch inside diameter standard galvanized steel pipe of required length with malleable iron pole plate

and guy clamp. Fasten the pole plate to the pole with a 3/8-inch thru bolt and 1/2-inch lag screws.

All guying components and hardware shall be galvanized in accordance with ASTM A123 or A153.

Anchors for guys shall be of the pressed steel four-way expanding fluke type or of the steel or malleable iron sliding plate type. The minimum unexpanded diameter shall be 8 inches, and the minimum expanded area shall be 110 square feet. Coat anchors with a black asphaltic paint.

Guy anchor rods shall be drop-forged steel, 3/4-inch diameter and 7-foot minimum length, threaded, of the single thimble eye type, with a square anchor bolt nut.

730.36 Pole Location

Install all signal support poles at the locations shown on the Plans or where directed by the Engineer.

COMPENSATION

730.37 Method of Measurement

Measurement for traffic signals will be on a per item basis for each item to be furnished and installed, as specified herein and shown on the Plans.

With regard to items for signal head assemblies, each item to be furnished, installed, or both furnished and installed shall be distinguished with a code number as follows:

1. The first digit is the number of faces per assembly.

2. The second digit will indicate the number of 12-inch lenses per assembly (including arrow lenses).

3. The third digit is the quantity of 8-inch lenses per assembly.

4. The letter "A" indicates an arrow lens and the digit following the "A" indicates the number of 12-inch arrow lenses per assembly.

5. The letter "H" or "V" indicates the arrangement of arrow signal lenses to be horizontal or vertical with respect to solid ball indications.

   EXAMPLE:

   1 5 0 A 2 H

   Digits indicate the following:

   1 = one face
   5 = five 12-inch lenses
   0 = zero 8-inch lenses
   A2 = two 12-inch arrow lenses
   H = Arrow lenses placed horizontally with respect to circular indications

A. Removal of Signal Equipment

The Department will measure items of equipment or material designated or required for removal on a per each intersection basis. Removal and salvage of all signal heads, poles, control equipment, cabinets, span wire, cable, and similar features to be performed at an intersection shall be included as a unit cost per each intersection. This includes the cost of stockpiling salvable equipment for pick-up by the appropriate agency, as noted in the Plans.

B. Signal Head Assembly (includes Pedestrian Signal Heads)

The Department will measure signal heads of the type shown on the Plans by the individual assembly complete in place, per each. This item shall include the signal heads, terminals, lamps, attachment hardware, cable connection, and testing.

C. Pull Box

The Department will measure each pull box of the type required as one complete unit, installed, per each. This item includes the pull box, excavation, backfilling, crushed stone base, and other incidental items as called for in the Plans or Standard Drawings.

D. Electrical Service Connection

The Department will measure Electrical Service Connections on a per each signal installation basis. This item includes the electrical service supplied to the weatherhead by the local utility, all necessary materials and labor for connection of the electrical service from the controller to the weatherhead, the wiring of the controller and detectors, and all incidentals necessary to render a complete and operable system.

E. Signal Cable

The Department will measure the length of Signal Cable of each size (number of conductors) installed in linear feet to the nearest foot from point to point along the routing for each cable.

The Department will make horizontal measurements by center to center measurement from:

1. Pole to pole
2. Pole to signal head (when terminating in a signal head)
3. Pull box to pull box
4. Pull box to pole
5. Pull box to pole-mounted or base-mounted controller

For cable inside mastarms, the Department will measure from center of vertical support to signal head where cable terminates.

The Department will make vertical measurement by one of the following:

1. For cable inside poles or conduit risers, the distance from ground level to the point of attachment of the span wire.

2. For cable inside mast arm supports, the distance from ground level to the mast arm connection.

3. For cable to pole-mounted controller,

    a. From ground level to bottom of controller.
    b. From bottom of controller to point of attachment of span wire.

4. For cable to pole-mounted signal head or pushbutton,

a. From ground level to bottom of signal head or pushbutton
b. From bottom of signal head or pushbutton to point of attachment of span wire.

The Department will make no additional allowance for slack length, length inside equipment or supports (except as noted), length for the required 360-degree drip loop, and similar instances requiring additional length of cable.

F. Span Wire

The Department will measure Span Wire Assembly, Tether Wire Assembly, and Messenger Cable by type in linear feet to the nearest foot. The measurement will be made from center to center of poles. These items include attachment hardware, strain insulators, and other hardware shown in the Plans as part of the assembly. The Department will make no additional allowance for slack length and other instances requiring additional length of wire.

G. Steel Conduit Riser Assembly

The Department will measure conduit riser assemblies per each for each size conduit riser installed on the outside of a pole, as shown on the Plans. This item includes conduit, weatherhead, condulet, fittings, nuts, washers, banding, clamps, grounding, and other items necessary for installation.

H. Conduit

The Department will measure conduit in linear feet to the nearest foot for each size and type of conduit installed.

The Department will measure underground conduit along the conduit by one of the following:

1. From the face of curb to the center of a pull box, pole or controller foundation,

2. From center to center of pull boxes,

3. From center to center of a pull box and a pole or controller foundation, or

4. From center to center of pole foundations or pole foundation and controller foundation.

The Department will add:

1. 1 foot to the above measurements for each entry to a pull box or pole foundation and each exit of a pull box or pole foundation.

2. 3 feet to the measurement for each capped extra entry (conduit stub) or exit to a pull box or pole foundation installed, as shown on the Plans.

3. 3 feet to the measurement for each connection between underground conduit and above ground riser.

4. 3 feet to the measurement for each entry or exit to a foundation for a base-mounted controller.

This item includes trenching, backfilling, sealing, capping, fittings, bushings, banding, grounding, and other accessories and hardware required for installation of the conduit system.

I. Vehicle Loop Detector (Amplifier)

The Department will measure vehicle detector loop amplifier per each unit, including the cable and associated hardware necessary to electrically connect the amplifier to the controller and loop lead in.

The Department will measure two and four channel card rack type amplifiers per each unit, including the cable, card rack(s), and associated hardware necessary to electrically connect the amplifiers to the controller and loop lead-ins.

J. Shielded Detector Cable

The Department will measure the two-conductor shielded detector cable installed between the controller cabinet and the loop detector wires in linear feet to the nearest foot.

The Department will make horizontal measurements (overhead and underground) by one of the following:

1. From center to center of pull boxes,
2. From center to center of pull box and pole,
3. From center to center of poles, or
4. From center to center of pull box or pole and controller foundation.

The Department will make vertical measurements by one of the following:

1. From ground level to the point of attachment of span wire, inside pole or conduit riser,
2. From the bottom of controller cabinet to the point of attachment of span wire, or
3. From ground level to the bottom of controller.

The Department will make no additional allowance for slack length, length inside equipment or supports (except as noted), splices, and similar instances requiring additional length of cable.

K. Saw Slot

The Department will measure the length of saw slot for installation of detection loop and lead wiring in linear feet to the nearest foot. Measurement for detection loops in the traffic lanes will be made based on the loop size shown on the Plans (the nominal length plus the nominal width) times 2. The Department will make no additional allowance for saw overruns to obtain full depth of saw slot or diagonal cuts to prevent sharp bends in the loop wire. The Department will measure saw slot for detection loop leads from the conduit entry at the face of curb or edge of pavement and along the route of the lead-in to the detection loop.

This item includes backing rods, or polyethylene foam sealant, loop sealant, and all other incidentals necessary to render a complete and operable system.

L. Loop Wire

The Department will measure the length of loop wire for installation of detection loops and lead-ins in linear feet to the nearest foot. Measurement will be made from the pull box or pole to the detection loop, around the loop the required number of turns and back to the pull box, pole, or point of splice. The Department will make no additional

allowance for slack length, length inside equipment or supports, splices, and similar instances requiring additional length of wire.

This item includes electrical connections, testing, and all other incidentals necessary to render a complete and operable system.

M. Controller

The Department will measure controllers as one complete unit, installed, per each. This item includes all auxiliary equipment shown the Plans to provide signalization control as shown on the Plans, and all hardware, including the cabinet (and cabinet foundation, if base-mounted), necessary for installation.

N. Wood Pole

The Department will measure Wood Poles, of the type and size shown on the Plans, per each, installed.

O. Guying Device

The Department will measure Guying Devices, of the type shown on the Plans, per each, installed. This item includes the guy wire, anchor, clamps, and all other components shown on the Plans necessary for installation.

P. Steel Strain Pole

The Department will measure Steel Strain Poles of the type and size shown on the Plans, per each, installed. This item includes the pole, foundation, anchor bolts, grounding, and all other hardware shown on the Plans necessary for a complete installation.

Q. Cantilever Signal Support

The Department will measure Cantilever Signal Supports, of the type and size shown on the Plans, per each, installed. This item includes the vertical pole shaft, mast arm, foundation, anchor bolts, grounding, and all other hardware shown on the Plans necessary for a complete installation.

R. Service Cable

The Department will measure two conductor power service cable, of the type and size shown on the Plans, in linear feet to the nearest foot, installed. Horizontal runs will be measured center to center of poles. Vertical runs will be measured from the ground to the weatherhead inside a pole or conduit riser, or from the ground to the bottom of the controller, or from the bottom of the controller to the weatherhead. This item includes all necessary attachment hardware. The Department will make no additional allowance for slack length or other instances requiring additional length of cable.

S. Pedestrian Pushbutton with Sign

The Department will measure Pedestrian Pushbutton with Sign as one complete unit, in place, per each. This item includes the pushbutton, sign, mounting hardware, wiring of pushbutton, testing, and all other incidentals necessary for a complete installation.

T. Pedestrian Signal Display with Pushbutton and Sign

The Department will measure Pedestrian Signal Display with Pushbutton and Sign as one complete unit, in place, per each. This item includes the signal heads, terminals, lamps, cable connections, pushbutton, sign, all attachment hardware, testing, and other incidentals necessary for a complete installation.

730.38 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Traffic Signal	Lump Sum
Removal of Signal Equipment	Each
Signal Head Assembly (Description)	Each
Install Pull Box (Description)	Each
Electrical Service Connection	Each
Signal Cable – (Description)	Linear Feet
Span Wire Assembly (___ pounds min. break strength)	Linear Feet
Tether Wire Assembly – __" Diameter	Linear Feet
Messenger Cable – __" Diameter	Linear Feet
Riser Assembly (Description)	Each

Conduit __" Diameter (Type)	Linear Feet
Vehicle Detector (Description)	Each
Shielded Detector Cable	Linear Feet
Saw Slot	Linear Feet
Loop Wire	Linear Feet
Controller (Description)	Each
Wood Pole (Description)	Each
Guying Device (Description)	Each
Steel Strain Pole (Description)	Each
Cantilever Signal Support (Description)	Each
Service Cable	Linear Feet
Pedestrian Pushbutton with Sign	Each
Pedestrian Signal Display with Pushbutton and Sign	Each

The unit price to be paid includes the cost of furnishing and installing, complete in place, each of the various types of equipment required by the Summary of Quantities shown on the Plans. Total payment is full compensation for all materials, labor, equipment, and incidentals necessary to produce a completely operative and finished installation of a traffic signal or traffic signal system as shown on the Plans and as specified herein, including restoration of pavements, sidewalks, and appurtenances damaged or destroyed during construction and tests. All additional materials and labor not specifically shown or called for, which are necessary to complete the traffic signal installation or traffic signal system described, will be considered incidental to the system and no additional allowance will be made.

SECTION 740 – GEOSYNTHETICS

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DESCRIPTION

740.01 Description

This work consists of placing geosynthetics in accordance with these Specifications and the Standard Drawings.

MATERIALS

740.02 Materials

Provide materials meeting the requirements of **921.12** for the type of geosynthetic shown on the Plans.

Furnish a certified laboratory test report from an approved testing laboratory with each shipment of materials. Laboratory test reports shall include the actual numerical test data obtained. Clearly label all rolls as being part of the same production run from which the test data was derived. Protect rolls to prevent damage during transportation, storage, and installation. Cover geosynthetic rolls during storage to protect against UV degradation, and store rolls elevated up off of the ground. Do not install material that is torn, punctured, or otherwise damaged.

CONSTRUCTION REQUIREMENTS

740.03 General

Place geosynthetics as shown on the Plans for the specific application. Compact the surface on which the geosynthetic is to be placed, as directed

by the Engineer. Prepare the surface to be as smooth as possible and free from debris, obstructions, and depressions that could result in gaps, tears, or punctures in the fabric during cover operations. Install the geosynthetic so that placement of cover material will not excessively stretch or tear the geosynthetic. After the geosynthetic is placed, install the initial lift of cover material within five calendar days. Do not operate equipment directly on the geosynthetic. Place cover material so that at least the minimum initial lift thickness, as specified by the Engineer, is between the geosynthetic and equipment tires or tracks at all times. Do not turn equipment and vehicles on the first lift above the geosynthetic.

Repair or replace, as directed by the Engineer and at no cost to the Department, materials that are damaged during or after placement.

COMPENSATION

740.04 Method of Measurement

The Department will measure geosynthetics of the type specified by the square yards, complete in place. No measurement for payment will be made for overlaps, splices, or sewn joints.

740.05 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Geomembrane	Square Yard
Geogrid Reinforcement	Square Yard
Cellular Confinement System (Description)	Square Yard
Geotextile (Type __) (Description)	Square Yard
Geotextile Tube	Linear Feet
Temporary Sediment Tube __" (Description)	Linear Feet

Such payment is full compensation for all labor, equipment, materials, tools, and incidentals necessary to complete the work.

PART 8 – ROADSIDE DEVELOPMENT

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SECTION 801 – SEEDING

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DESCRIPTION

801.01 Description

This work consists of furnishing and placing seed, commercial fertilizer, agricultural limestone, and mulch material on all newly graded earthen areas that are not to be paved, stabilized, or sodded.

MATERIALS

801.02 Materials

Provide materials as specified in:

Water **802.02.B.5**
Mulch Binder: Emulsified Asphalt, Type SS-1 or AE-3 ..... **904.03**
Grass Seed **918.01**
Commercial Fertilizer **918.02**
Agricultural Limestone **918.04**
Mulch Material **918.05**
Inoculant for Legumes **918.06**
Liquid Lime ..... QPL

801.03 Reserved

CONSTRUCTION REQUIREMENTS

801.04 General

Perform seeding work as specified in **209**.

At the start of permanent seeding operations, prepare, shape, and dress the area to be seeded as specified in **203.08** and **801.05**. Unless otherwise directed by the Engineer, do not sow the seed until after placing the topsoil as specified in **203.06**. Use topsoil with all permanent seeding activities except where its use would be detrimental to effective erosion and siltation control, as determined by the Engineer.

The Contractor may perform Temporary Seeding (with Mulch) or Temporary Seeding (without Mulch) without full preparation of the seedbed as specified in **801.05**, where approved by the Engineer, and application of permanent erosion and siltation control measures is not practicable.

Perform all seeding and related operations as continuous operations.

A unit in relation to seeding area is 1,000 square feet. For purposes of measuring water, a unit is 1 M.G., which equals 1,000 gallons.

801.05 Preparing the Seedbed

When the soil is in a tillable and workable condition, prepare the seedbed in the following manner and sequence:

1. Scarify, disc, harrow, rake, or otherwise work each area to be seeded until it has been loosened and pulverized to a depth as directed by the Engineer.

2. Incorporate fertilizer, at the rate of not less than 20 pounds of Grade 10-10-10, or equivalent, per unit (1,000 square feet), and agricultural limestone, at the rate of not less than 100 pounds per unit, uniformly into the soil for a depth of approximately 1/2 inch.

3. If the soil pH is below 5.5, in addition to the required agricultural lime, apply liquid lime selected from the Department's QPL at a rate of 7.5 gallons per acre (22 ounces per 1,000 square feet).

Incorporating fertilizer into the soil as specified above is not necessary when mixed with seed in water and applied with power sprayer equipment.

801.06 Seeding

The specific seed group will be shown on the Plans or as directed by the Engineer from those specified in **918.01**.

Sow the seed immediately after preparing the seedbed as specified in **801.05**. Sow the seed uniformly using a rotary seeder, hydraulic equipment, or other satisfactory means, at the rate specified in Table 801.06-1, unless otherwise specified or directed.

Table 801.06-1: Seed Application Rates

Seed Group	Application Rate, Pounds per Unit (1,000 square feet)
A, B, and C	2.5
B1	0.6
All other groups specified in **918.01**	1.5

Before sowing, inoculate Group C seed and seeds of legumes, when sown alone, in accordance with the recommendations of the inoculant manufacturer and as directed by the Engineer.

Do not perform any seeding during windy weather or when the ground surface is frozen, wet, or otherwise non-tillable. Do not perform seeding during December and January unless otherwise allowed.

801.07 Mulching

When seeding with mulch is specified, use hay, straw, or other approved mulch materials.

When using hay or straw as the mulching material, spread it evenly over the seeded area, immediately following the seeding operations, at an approximate rate of 100 pounds per unit for straw and 150 pounds per unit for hay. The Engineer may vary this rate, depending on the texture and condition of the mulch material and the characteristics of the area seeded.

To hold hay or straw mulch in place, apply an approved tackifier, listed on the QPL, as recommended by the manufacturer.

When using wood fiber mulching material, apply it at a rate of 28 to 35 pounds per unit, using hydraulic mulching equipment. Spray the material uniformly on the surface of the prepared seedbed. Adjust the application rate as directed by the Engineer.

801.08 Care During Construction

Maintain all seeded areas to the Engineer's satisfaction until acceptance of the Work.

Repair, as directed by the Engineer, all areas previously seeded and mulched in accordance with this Section but that incurred damage or failed to successfully establish an acceptable stand of grasses or legumes. Furnish all material and labor required to repair seeded areas damaged due to Contractor negligence at no cost to the Department. The Department will measure and pay for repairs made to seeded areas, except temporary seeding, required through no fault of the Contractor, in accordance with **801.09** and **801.10**. If the Engineer directs the Contractor to place additional fertilizer on the area to be reseeded, apply additional liquid lime at a rate of 5 gallons per acre (15 ounces per 1,000 square feet) if the pH of the soil is below 5.5.

After an acceptable stand of grass has been attained, top-dress seeded areas with not less than 10 pounds of fertilizer of Grade 10-10-10, or equivalent, per unit at approximately 6-month intervals, unless otherwise specified or directed.

COMPENSATION

801.09 Method of Measurement

A. Seeding

The Department will measure the seeded area for payment by the number of units seeded in accordance with these Specifications and accepted by the Engineer. Each unit shall consist of 1,000 square feet measured along the surface.

B. Mulch

The Department will measure mulch for payment complete and in place, including tackifiers used to hold the mulch in place.

C. Water

The Department will measure water necessary for seedbed preparation and maintenance by the M.G. (1,000 gallons) using calibrated tanks or distributors, or accurate water meters.

The Department will not measure water used in applying seed, fertilizer, and mulch binder.

D. Repairs of Seeded Areas

The Department will measure supplemental items used to repair seeded areas on which a satisfactory stand of grasses or legumes has not been obtained due to causes not attributable to Contractor negligence as provided below. These items will only be used when the reseeding is confined to small areas that would not restrict the Contractor's operation. If the areas to be reseeded are of substantial size, thereby accommodating the Contractor's normal operation, the Contractor shall perform the work in accordance with these Specifications, and the Department will pay for such work under the applicable original seeding item.

1. The Department will not pay for seedbed repair directly, but will consider the cost thereof as included in the unit price bid for Seed (Supplemental Application). If additional materials are required to repair the seedbed, the Department will make payment under the appropriate item or items in **203**.

2. The quantity of seed measured for payment to repair seeded areas will be the actual number of pounds of seed used, as determined by bag count of standard weight bags or by weighing the seed on approved scales.

3. The quantity of fertilizer measured for payment will be the actual number of tons of dry fertilizer used as determined by bag count of standard weight bags or by weighing the fertilizer on approved scales. If liquid fertilizer is used, the weight will be converted to its equivalent dry weight in tons.

E. Fertilizer

The Department will measure fertilizer applied, as specified or directed, to areas with an acceptable stand of grass as specified in **801.09.D.3**.

F. Lime

The Department will measure lime for payment complete and in place by the ton.

The Department will make no direct measurement or payment for agricultural limestone or liquid lime used in repairing seeding areas, but will consider the cost to be included in the unit price bid for Fertilizer.

801.10 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Seeding (with Mulch)	Unit
Crown Vetch Mixture (with Mulch)	Unit
Temporary Seeding (with Mulch)	Unit
Seeding (without Mulch)	Unit
Crown Vetch Mixture (without Mulch)	Unit
Temporary Seeding (without Mulch)	Unit
Mulch	Unit
Seed (Supplemental Application)	Pound
Fertilizer (Supplemental Application)	Ton

Payment for Seeding, Crown Vetch Mixture, and Temporary Seeding is full compensation for preparing the seed bed, furnishing and placing all materials, including fertilizer, agricultural limestone, seed, mulch materials and mulch binder where mulch is used, and inoculant, if specified.

When the Contract does not provide for a unit bid price for Seeding (without Mulch) and this item is used for temporary or permanent erosion control, the Department will make payment at a rate per unit equal to 0.45 times the unit price bid for Seeding (with Mulch). In addition, if the Contract does not provide a unit bid price for mulch and mulch alone is required, the Department will make payment at a rate per unit equal 0.60 times the unit price bid for Seeding (with Mulch).

The Department will pay for Water used to prepare the seed bed and for maintenance at the contract unit price per M.G. (1,000 gallons) of water, which payment is full compensation for furnishing and applying the water as specified.

Payment for Seed (Supplemental Application) is full compensation for minor seedbed repair, mulch materials and mulch binder, and inoculant, if specified.

Payment for Fertilizer (Supplemental Application) and fertilizer applied after an acceptable stand of grass has been attained is full compensation for furnishing and applying fertilizer and, where required, liquid lime.

SECTION 802 – LANDSCAPE PLANTING

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DESCRIPTION

802.01 Description

This work consists of furnishing and planting trees, shrubs, seedlings, and ground cover of the kinds and at the locations shown on the Plans or where directed by the Engineer.

MATERIALS

802.02 Materials

A. Planting Material Standards

Before performing any work, furnish proof of having secured a nursery dealer's certificate for each shipment of plants. The certificate shall indicate the number of plants of each species in the shipment and the project number for which the plants are intended. The certificate shall also include a certification that the plant materials conform to the requirements of the Plans and these Specifications, and that all local, State, and Federal laws pertaining to the inspection, sales, and shipment of plant materials have been complied with.

Consider "collected plant material" to mean plants that are not nursery grown. Do not use collected plant material unless shown on the Plans. Dig collected plant material called for on the Plans with a ball of earth having a minimum diameter at least 25% greater than that specified for nursery grown stock, and wrap in burlap. Handle plants so as to keep their roots protected at all times. During delivery, ensure that the entire load remains suitably covered. Coverings shall not be so tight as to cause heating.

1. **Names and Grades.** Plant material shall conform to the nomenclature of *Standardized Plant Names*, as adopted by the Joint Committee of Horticulture Nomenclature, latest revision. Size and grading standards shall conform to the latest approved revision of the *American Standard for Nursery Stocks*, Z60.1, published by the American Nursery and Landscape Association. Make no substitutions of size or grade without the Engineer's written permission. Properly identify each bundle of plants and all separate plants with legible, waterproof tags securely fastened to each plant or bundle of plants.

   Ship plants as follows:

   a. Seedlings in bundles of 100.
   b. Bare Root in bundles of 10.
   c. Ball and Burlap individually.

2. **Health.** Provide plants conforming to the following health requirements:

a. All plants, including their roots, shall be free of disease, insects, or other injurious qualities.

b. The trunk bark of all trees shall be sound, trees shall have no large wounds, and small wounds shall have a satisfactory callus roll formed or forming over them.

c. Plants shall show good annual growth.

d. Buds shall be plump and well filled for the species.

e. Evergreen foliage shall be of good intense color.

3. Quality. All plants shall:

a. Be true to type;

b. Have normal, well developed branch systems, and a vigorous fibrous root system;

c. Be sound, healthy, vigorous plants free from defects, disfiguring knots, sunscald injuries, abrasions of the bark, plant diseases, insect eggs, borers, and all forms of infestation; and

d. Have been growing in the same climatic conditions as the location of the Project for at least 2 years prior to the date of the Contract.

4. Ball and Burlap/Wire Basket. All balled and burlapped plants shall conform to the *American Standard for Nursery Stock*, Z60.1, latest approved revision. All balls shall be of natural earth in which the plant had been growing. Manufactured or artificially produced or mudded-in balls are not acceptable. Ensure that balls are firm and unbroken. The Engineer may reject balled and burlapped plants if they fail to meet good digging and handling practices.

5. Container Grown Plants. In addition to the requirements of the *American National Standard for Nursery Stock*, Z60.1, container grown plants shall conform to the following:

1. The space between the rim or top of the container and the soil line within the container shall not be more than 1-1/2 inches for the 1-gallon and 2-gallon sizes and not more than 2-1/2 inches for the 5-gallon size.

2. Encircling roots shall not have grown in such a manner that they will cause girdling of the trunk or stems. If encircling roots do exist, they shall be cut.

3. Roots shall not protrude through drainage holes or over the rim of the container to the extent that they will be damaged while removing the root ball from the container.

4. Plants shall have been acclimated to outside conditions. Container grown plants may be used provided the Engineer approves of their use in writing.

B. Miscellaneous Planting Materials

Obtain the Engineer's approval of the following materials before incorporating them in the work:

1. Topsoil. Provide a natural, friable, fertile, fine sandy loam possessing the characteristics of representative topsoils in the vicinity that produce heavy growths of vegetation. The topsoil shall be free from subsoil, noxious weeds, stones larger than 1 inch in diameter, lime, cement, ashes, slag, and other deleterious matter. Topsoil shall be well drained in its original position and free from toxic quantities of acid or alkaline elements.

2. Mulch. Unless otherwise specified, provide a standard, commercial quality of aged hardwood bark mulch with a particle size of less than 3 inches and a contamination rate less than 0.5% by volume.

3. Fertilizer. Unless otherwise shown on the Plans, do not fertilize trees.

4. Tree Wrappings. Avoid using tree wrappings for any purpose other than providing protection during transport.

5. Water. For planting work, use water that is free from harmful or objectionable qualities or organisms.

6. **Stakes for Bracing and Anchoring.** Stakes used for guying trees shall be at least 6 feet long, of sound, sturdy material, reasonably capable of withstanding aboveground and underground conditions. Their top and bottom face dimensions shall be at least 2 x 2 inches, or a minimum diameter of 2-3/4 inches, or a substitute approved by the Engineer.

7. **Hose.** For staking, use a new fabric-bearing rubber hose with an inside diameter of not less than 1/2 inch.

8. **Straps.** For staking, use straps consisting of flat, canvas belting with grommets.

802.03 Reserved

CONSTRUCTION REQUIREMENTS

802.04 Time and Condition of Planting

Unless otherwise specified, perform all planting after the growing season, between the dates of November 1 and April 1.

802.05 Staking

The Engineer, or the Contractor when specified, will stake all plant and bed locations in accordance with the plant list and approximate locations shown on the Plans.

Perform the planting at the approved locations. After planting is complete, outline the ground cover areas and seedling areas with painted stakes and twine as directed by the Engineer.

802.06 Tree Planting

A. Planting Pits

Form circular planting pits with vertical sides. Make the diameter of the pits at least 2 feet greater than the diameter of the ball of the tree. The depth of the pit shall be sufficient to accommodate the ball or roots of the tree when the tree is set to the finished grade, allowing for a maximum of 1 inch of tamped spoil below the roots of the plant.

B. Backfill

Backfill for tree planting shall consist of spoil material removed from the hole if suitable. If not, this material may be blended with 50% topsoil. Soil amendments are not recommended.

C. Setting of Trees

Place all plants at a level so that, after settlement, the natural relationship between the original grade at which the plant grew and the present one shall be the same. The root flare should be level with the soil grade surrounding the tree. Plant trees plumb, and orient them for desired effect as directed by the Engineer. Tamp spoil material from the hole around the base of each ball to fill all voids. Place material in 6 to 8-inch thick layers, thoroughly tamping each layer to prevent air pockets.

Cut back burlap and wire baskets, and remove a minimum of one-third of the depth of the root ball. Remove all string from the root ball and around the trunk. When planting bare root trees, carefully work soil around the roots and spread them in a natural position before backfilling. Form, around all trees, shallow basins or saucers, which are slightly larger than the diameter of the ball, to hold additional water.

Thoroughly water all plants immediately after planting, fully saturating the backfill in the pits and beds during the same day of planting. Perform planting and watering as one continuous operation. If applying water by hose, use an open end hose at very low pressure to avoid air pockets and injury to the roots.

D. Guying and Staking

Only stake trees when necessary to keep them vertical on a slope or in an area with strong winds. Never stake trees less than 6 feet tall or under 1 inch caliper. When staking is necessary, use biodegradable underground staking, or soft straps or flexible hose without wire. Ensure that staking allows for free movement of the tree trunk.

802.07 Wrapping and Pruning of Trees

A. Wrapping

Wrap tree trunks for transport, and then completely remove all wrapping bandage and string at the time of planting.

B. Pruning

Except for branches damaged during digging and transport, do not prune trees at the time of planting unless otherwise directed.

Do not use tree paint on cuts.

802.08 Shrub Planting

A. Planting Beds and Pits

Prepare planting beds to a depth of 4 to 6 inches, or as directed by the Engineer. Make plant pits 6 inches deeper and 6 inches greater on all sides than the plant balls.

B. Prepared Topsoil

Backfill for shrub planting shall consist of "prepared topsoil" as specified in **802.06.B**.

C. Setting of Shrubs

Set shrubs as specified in **802.06.C**.

D. Pruning of Shrubs

Except for removing broken or badly bruised branches with a clean cut, do not prune trees at the time of planting unless otherwise directed.

Do not use tree paint on cuts.

802.09 Seedling Planting

This Specification is intended to produce natural appearing wooded areas similar to others in the vicinity. To achieve this effect, mix and plant seedlings specified for a given area as shown on the Plans.

Dig holes to receive these plants of sufficient size and depth to place the roots in a normal position, and to allow the plant to be set slightly below grade, leaving a depression to receive and hold water.

After planting the seedlings, provide a thorough watering on the same day. Perform planting and watering as a continuous operation.

After completing the planting, ensure that each plant is solidly in the ground and thoroughly wetted.

802.10 Ground Cover Planting

Ground cover planting shall consist of an overplanting of existing grasses or other growing material. Dig holes to receive these plants of sufficient size and depth to accommodate the roots and to allow the plant to be set slightly below grade, leaving a slight depression to receive and hold water. Place 2 inches of topsoil under the plant and around the roots. Carefully remove containers, except those of organic material, from pot-grown plants to avoid damaging the soil ball.

Perform planting and watering as a continuous operation, thoroughly watering on the same day as planting. This may be done by mechanical means if adequate equipment is available. When watering is complete, ensure that each plant has been thoroughly wetted and that the plant is solidly in the ground.

802.11 Temporary Storage and Heeling-In

Ship plants directly from the nursery. When temporary storage or heeling-in is required, provide and prepare a suitable heeling ground or heeling-in nursery conveniently located near the planting site before shipping the plant material from the growing nursery or other source. Take care in requesting shipment so as to avoid long periods of temporary storage.

Immediately heel-in, or transport to the planting site and plant, all plant material delivered to the Project. The Engineer will reject material left out

of ground overnight or left with its roots bare to the sun and wind, or otherwise left unprotected during transit, unloading, or storage.

802.12 Mulching

Within 2 days of planting trees and shrubs, apply a 4-inch depth of mulch, entirely covering the saucer of individual tree pits and the entire shrub beds. Ensure that mulch does not touch the tree trunk or the stems of shrubs.

802.13 Final Cleanup

Upon completion of all operations described in these Specifications, remove all refuse, brush, including standing dead and rejected plants, sticks, packaging, potting debris, and similar waste, regardless of whether it was directly connected with the Work or previously left by others. Leave the general area in a neat and orderly condition that meets the Engineer's approval.

802.14 Period of Establishment

Installation of the plant material shall be regarded as partial completion of the horticultural work. The "period of establishment" will be April 1st through November 1st. The Contractor is responsible for all plantings for one full period of establishment.

Keep all plants and plant material installed in a living, healthy condition up to the date for termination of Contractor responsibility for care specified herein. Unless otherwise specified by the Engineer, perform the following work in a continuous manner during the period of establishment

A. Watering

During periods of low rainfall or drought, water all woody plants at weekly intervals unless otherwise directed by the Engineer. Slowly and gradually apply sufficient quantities of water until the root area of the plants is saturated. One inch of water is customary. Apply sufficient quantities of water slowly and gradually until the root area of the plants is saturated. Carefully adjust both the force and volume of water to ensure that no damage occurs to plants, backfill, and mulching material.

B. Cultivating

When shown on the Plans, keep all planting areas free from grass and weeds throughout the entire growing season. Always keep the area clean, open, and properly mulched, unless covered with plastic and mulched. Closely mow areas such as slope bed plantings.

802.15 Inspection and Replacement of Plants

A. Initial Inspection and Replacement of Plants

The Engineer will initially inspect the plants during and before the end of the planting season (April 1st), and will determine the necessity of replacing dead, degenerated, defective, or missing plants. Remove plants fitting into the above categories and plants that are stagnant, whether technically alive or not, and replace them with the specified plants at no cost to the Department. For each plant replaced, perform all necessary work to establish the plant, regardless of already fulfilled obligations regarding other plant material on the site. Based on the findings of the Engineer's initial inspection as addressed above, replace all plants that are required to be replaced on or before May 1st.

B. Final Inspection: Replacement and Acceptance of Plants

The Engineer will conduct a final inspection of planting, during and before the end of the first full growing season, and on or about October 1st, after the first full growing season. The Engineer will determine whether to require the Contractor to replace plants as specified in **802.15.A** or if such replacement would be inadvisable due to seasonal or other conditions.

The Contractor's responsibility for care of all plantings that are acceptable on the date of the final inspection mentioned above shall end on that date.

Based on findings of the inspection mentioned above, replace plants that require replacement with plants of the same species, size, and quality at no cost to the Department. Replace non-viable plants before the 15th of February. Upon completion of the work, the Engineer will inspect the replacement plantings and accept or reject the work. If accepted, the Contractor's responsibility for care of the replacement plantings shall end on the date of the Engineer's inspection.

COMPENSATION

802.16 Method of Measurement

The Department will measure:

1. Living trees, seedlings, and shrubs for payment by the unit (per each).

2. Ground cover by the square yard, in accordance with **109**.

3. Water required for the plant establishment by the M.G. (1,000 gallons).

The Department will only measure for payment those plants in a living, healthy condition at the time the Contractor's responsibility for care of the plants has ended.

The Department will not measure or make payment for water used in plant installation work.

802.17 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Trees (Description)	Each
Seedlings (Description)	Each
Cuttings (Description)	Each
Shrubs (Description)	Each
Ground Cover (Description)	Square Yard
Water (Plant Establishment)	M.G. (1,000 gallons)

In making partial payments for planting items, the Department will consider:

1. Approximately one-third of the Contract price to be the value of preparing the holes for planting including placement of prepared mixtures,

2. Approximately one-third as the value of the furnishing and planting of the original plants, and the

3. Remaining one-third as the value of the plant establishment work.

The Department will make partial payments for the plant establishment work as the work progresses, at times to be established by the Engineer at intervals of not less than three months.

SECTION 803 – SODDING

803.01 Description 903
803.02 Sod 904
803.03 Fertilizer Grade 905
803.04 Ammonium Nitrate 905
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803.12 Method of Measurement 908
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DESCRIPTION

803.01 Description

This work consists of furnishing and placing sod at the locations shown on the Plans or where directed by the Engineer.

Ordinarily, this work will consist of furnishing and placing new sod originating from sources outside the right-of-way. In some cases, however, the work will include removing sod from areas where the requirements of the improvement would destroy existing sod, storing the sod so removed, and resetting it in areas shown on the Plans or designated by the Engineer.

MATERIALS

803.02 Sod

A. General

Provide new sod consisting of live, dense, well-rooted growth of permanent grasses, free from Johnson grass, nut-grass, and other undesirable grasses or weeds, that is well-suited for the intended purpose and for the soil in which it is to be planted. Correct installed sod that does not meet these requirements as directed by the Engineer and at no additional cost to the Department.

Cleanly cut all sod in strips having a reasonably uniform soil thickness of not less than 1 inch and a reasonably uniform width of not less than 8 inches and a length of not less than 12 inches.

B. Department of Agriculture Inspection and Authorization

The sale or movement of turf grass or sod for propagation is controlled by Tennessee Plant Pest Act of 1955, TCA 43-515, et. seq. It requires inspection during the growing season and authorization by the Tennessee Department of Agriculture prior to removal. The authorization may be certificates for "Tennessee Certified Premium" sod, or "Tennessee Certified" sod. If the sod offered for use will not meet the requirements for certified sod but will meet the requirements of this Subsection, obtain a "Permit for Movement of Non-certified Turf Grass Sod."

Request the inspection from the Tennessee Department of Agriculture as early as possible to avoid undue delay. Include the following information in the request for inspection:

1. Project number, county, name and address of the owner or seller,
2. Name and address of purchaser,
3. Kind or variety,
4. Exact location of sod,
5. Location where sod will be used, and
6. Approximate date movement of sod will begin.

Direct the request for inspection to the following address:

Division of Plant Industries
Tennessee Department of Agriculture,
Ellington Agricultural Center
Melrose Station 40627
Nashville, Tennessee 37204
Telephone (615) 360-0130

Furnish a copy of the Department of Agriculture authorization to the Engineer before removing any sod.

803.03 Fertilizer Grade

Provide fertilizer conforming to **918.02** and that is of Grade 10-10-10 or 1-1-1 formula unless otherwise shown on the Plans or specified in the Special Provisions.

803.04 Ammonium Nitrate

Provide ammonium nitrate conforming to **918.03**.

803.05 Agricultural Limestone

Provide agricultural limestone conforming to **918.04**.

803.06 Reserved

CONSTRUCTION REQUIREMENTS

803.07 Weather Limitations

Set or reset sod only when the soil is moist and favorable to growth. Do not perform any setting or resetting between December 1 and February 1, unless weather and soil conditions are considered favorable and permission is granted by the Engineer.

803.08 Removing and Storing Sod for Resetting

Cut, handle, and store sod removed from such areas as lawns, yards, and lots so that the sod can be reset in the same locations from which it was removed. Do not substitute sod unless approved by the Engineer. Unless resetting sod immediately after cutting, stack the sod in piles, and keep it

moist until reset. Reset sod within 7 days after removal, unless otherwise approved by the Engineer.

803.09 Sodding

Bring the area to be sodded to the lines and grades shown on the Plans. Unless otherwise directed by the Engineer, place topsoil as specified in **203.06** before placing sod. When laying sod adjacent to structures, ditch paving, sidewalks, and similar features, ensure that water will not pond, but will flow as designed. Loosen the surface of the ground to be sodded to a depth of not less than 1 inch with a rake or other device. If necessary, sprinkle the ground until saturated for a minimum depth of 1 inch, and keep moist until the sod is placed. Immediately before placing the sod, apply fertilizer and lime uniformly to the prepared surface of the ground. Apply fertilizer at the rate of 12 pounds of Grade 10-10-10, or equivalent, per 1,000 square feet. Apply agricultural limestone at the rate of 100 pounds per 1,000 square feet.

Place sod as soon as practicable after removing from the point of origin, and keep it in a moist condition during the interim. On urban projects, place the sod on all newly graded cut and fill slopes as work progresses to prevent damage to adjacent facilities and property due to erosion. Take care to retain the soil on the root system during excavating, hauling, and planting. Ensure that all sod is in an acceptable condition upon delivery and placement at the work site. Do not use sod damaged by heat or dry conditions.

Carefully place the sod by hand on the prepared ground surface, with the edges set in close contact and, as far as possible, in a position to break joints. Lay and fit each strip of sod into place, thoroughly wet it, and roll with an approved roller or hand-tamp, as approved by the Engineer. On slopes of 2:1 or steeper, pinning or pegging may be required to hold the sod in place.

803.10 Period of Establishment

A. Watering

Provide all labor and arrange for all watering necessary for rooting of the sod. If rainfall during the first 14 days of the period of establishment is inadequate to maintain a moist soil, perform the necessary watering, as approved by the Engineer. After 14 days, apply

ammonium nitrate at the rate of 3.5 pounds per 1,000 square feet, and re-water the sod.

B. Department Inspection

An authorized representative of the Department will conduct an inspection to determine the acceptability of the sodding no less than 90 days but not more than 150 days after completion of the sod work or at the acceptance of the entire Project, whichever is later, except that the Engineer may delay the inspection when conditions are such that the acceptability of the sodding cannot be determined at the end of the 150-day period or at the time the entire Project is accepted.

C. Contractor Guarantee

The Contractor shall guarantee, at the time of the Department inspection, a minimum of 95% live sod on the sodded areas and that there are no vacant areas of dead sod larger than 100 square feet. This guarantee shall apply to all permanent sodding performed in conjunction with the Project, regardless of the type protection used or the season in which the sodding is performed.

D. Repairs of Defective Areas

When the sodding does not meet the guarantee requirements at the time of inspection, repair the defective areas. Required repairs may include preparing the sod bed, refertilizing, resodding, and providing any erosion control items that were originally required. Perform such work as soon as favorable working conditions occur after being advised of the repairs required. The Department will not pay for the repair work and materials required to fulfill the guarantee requirements.

E. Care and Maintenance

From the time sodding and protection work begins until the date the entire Project is accepted, keep all sodded areas in good condition at all times.

Do not allow placement of any equipment or material on any planted area, and erect suitable barricades and guards to prevent equipment, labor, or the public from traveling on or over all areas planted with sod.

Promptly repair damage to sodded areas as directed by the Engineer. Perform all work and provide all materials necessary to protect, maintain, and restore sodded areas during the life of the Contract at no additional cost to the Department, except for additional work caused by Department-requested changes. If it becomes necessary to disturb previously sodded areas due to slope changes, addition of paved ditches not previously located by the Engineer, or other changes made at the direction of the Engineer, the Department will make payment for a reasonable amount of additional work, as determined by the Engineer, at the original contract unit prices. The Department will not pay for additional work due to changes made for the benefit of the Contractor, such as slope changes to obtain balance excavation instead of borrow excavation, nor will the Department pay for additional work required because the Contractor failed to properly coordinate its erosion control schedule thus causing previously sodded areas to be disturbed by operations that could have been performed before sodding.

F. Contract Time

If, on Contracts involving sodding and other items of construction, the other items have already been completed, the time required for establishment under this item will not be charged against the time stipulated in the Contract for completion of the Project.

803.11 Disposal of Surplus Material

Dispose of all surplus material as directed by the Engineer.

COMPENSATION

803.12 Method of Measurement

The Department will measure:

1. Sod by the square yard in accordance with **109**.

2. Water by the M. G. (1,000 gallons) using calibrated tanks or distributors, or accurate water meters.

Only areas upon which sod has been set or reset will be measured for payment.

803.13 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Sodding (New Sod)	Square Yard

The Department will pay for water applied during the first 14 days after sodding work is complete, including the water used in the re-watering of the sod after the application of the ammonium nitrate, at the contract unit price for Water per M.G. (1,000 gallons). Water applied after this period will not be paid for and will be considered incidental to other items.

SECTION 805 – EROSION CONTROL BLANKETS

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DESCRIPTION

805.01 Description

This work consists of furnishing and placing erosion control blankets, listed on the QPL, over previously prepared and seeded areas as shown on the Plans or as directed by the Engineer.

MATERIALS

805.02 Materials

Provide materials as specified in:

Erosion Control Blankets **920.01**
Staples **920.02**

805.03 Reserved

CONSTRUCTION REQUIREMENTS

805.04 Surface Preparation and Blanket Placement

Shape, fertilize, and seed the areas to receive the erosion control blankets as shown on the Plans or as directed by the Engineer. The surface shall be

smooth and free of depressions and eroded areas that would allow water to collect or flow under the blanket.

Place the appropriate type of blanket as specified within 24 hours after the area has been seeded and prior to any rain or watering. If using a jute mesh blanket, after stapling the blanket into place, press it into the ground with a light lawn roller or by other means approved by the Engineer.

Place the blankets as shown on the Plans and Standard Drawings. Drive staples vertically into the ground to anchor the plastic mesh. Space staples as shown on the Plans and Standard Drawings. Where blankets are laid side by side, place the staples so that the staple will anchor mesh from each blanket.

In waterways, ditches, flumes, and channels, unroll the blanket and place in contact with the soil in the direction of the flow of water. The Engineer may specify additional staples or check slots in waterways where slopes are steep or large water volumes or velocities are anticipated.

805.05 Maintenance

Maintain the blanket installation during the life of the Contract. Prior to Project acceptance, if any staples have become loosened or raised, or if the blanket becomes loose, torn, or undermined for any reason, reshape, re-seed, and re-fertilize the damaged areas, and satisfactorily repair or replace the blanket at no additional cost to the Department.

COMPENSATION

805.06 Method of Measurement

The Department will measure blankets of the specified type(s), installed and accepted, by the square yards complete in place. The Department will consider overlaps, over width, and cut anchor slots to be incidental to the work.

805.07 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Erosion Control Blanket (Type __)	Square Yard
Turf Reinforcement Mat (Class __)	Square Yard
Flexibly Channel Liner (Class __)	Square Yard

Such payment is full compensation for all materials, equipment, tools, labor, and incidentals, including maintenance.

The Department will pay for the preliminary preparation of the areas on which the blanket is to be placed, including placing topsoil and furnishing and applying all seed, fertilizer, and water, under their specific item numbers.

SECTION 806 – ROADSIDE MAINTENANCE

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DESCRIPTION

806.01 Description

This work consists of litter/debris removal, mowing, and trimming as specified or as directed by the Engineer for the entire highway right-of-way where accessible (fence-to-fence where applicable), including shoulders for the length of the Project.

CONSTRUCTION REQUIREMENTS

806.02 General

Remove litter and debris as directed by the Engineer for the entire construction limits. Dispose of litter and debris in accordance with all applicable permits and state and local ordinances.

Mowing and vegetation removal work shall consist of mowing and trimming of the right-of-way for vegetation control to maintain a neat aesthetic appearance as directed by the Engineer.

806.03 Definitions

A. Litter

Litter refers to any object or group of objects foreign to the right-of-way that has been discarded or abandoned and is or may become

visible from the edge of the roadway or shoulder as a result of mowing, vegetation management, construction, maintenance operations, or traffic. Examples under this definition include but are not limited to paper, plastic, bottles, cans, wood, tires, portions of tire, and metal products.

B. Mowing

Mowing refers to the work associated with cutting or trimming vegetation, primarily consisting of, but not limited to, grasses, invasive weeds, and small trees or shrubs to provide a consistent and aesthetically pleasing standing vegetation height as directed by the Engineer.

C. Trimming

Trimming refers to the work associated with cutting or trimming vegetation in close proximity to objects or in areas not accessible to conventional mowers in an attempt to prevent damage and provide a consistent vegetation height.

806.04 Time and Frequency

Perform litter/debris removal a minimum of twice per year or as directed by the Engineer.

Perform mowing and trimming a minimum of twice per growing season or as directed by the Engineer. The Engineer will issue a notice to begin to the Contractor at least 5 days before the date the mowing cycle is to begin.

Only perform work during the hours of daylight Monday through Saturday, or as directed by the Engineer. Do not perform this work on Sunday.

806.05 Mowing Operations

Perform all mowing to the satisfaction of the Engineer. Cut standing vegetation to a height of 4 inches while maintaining a consistent vegetation profile within the construction limits. Mow only those areas that are designated as mowable acres, including, if present, a minimum of 5 feet up the back slope from the bottom of the ditch, and 5 feet behind all guardrails. To cut vegetation, including small trees, shrubs, and bushes with a stem diameter of up to 1 inch that are inside of and encroaching upon the established mowing limits, use a mower or hand trimming methods as

directed by the Engineer. Take care not to damage the trees, plants and shrubs that are designated by the Engineer to remain. Hand trimming may be required as directed by the Engineer for areas of vegetation inside the designated mowing limits that are not accessible to mechanical mowers. As work progresses, conduct mowing and trimming so as to provide a consistent standing vegetation height in all mowing limits adjacent to the roadway. Mow as close as practicable to all fixed objects. Perform hand atop earth berms, within all rip rap areas, and around all fixed objects, including but not limited to earth berms, guardrails, cable rail, utility installations, utility poles, mailboxes, delineators, sign posts, wildflower plots, bridge abutments, and bridge piers. Do not apply chemicals unless authorized by the Engineer. Actual dimensions and mowing limits shall be discussed at the Preconstruction Conference.

Mowing for site distance shall be performed as frequently as necessary to provide adequate visibility and will not be considered as part of a mowing cycle.

COMPENSATION

806.06 Method of Measurement

The Department will not measure litter/debris removal for payment but will consider it incidental to the Work unless otherwise specified in the Contract.

The Department will pay for Mowing and Vegetation Removal by the mowing cycle. A mowing cycle includes the mowing of all areas within Project limits with overgrown vegetation one time.

The Department will not measure mowing for site distance, but will consider it incidental to the Work.

806.07 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Mowing and Vegetation Removal	Mowing Cycle

806.07

All costs associated with mowing and vegetation removal shall be included in the unit bid price for mowing. If the Contract does not contain a pay item for Mowing and Vegetation Removal, it will be incidental to other items of Work.

PART 9 – MATERIALS

SECTION 901 – HYDRAULIC CEMENT 918
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901.01 Hydraulic Cement

Provide hydraulic cement, selected from the Department's QPL, that conforms to the following for the kind and type specified or allowed:

Portland cement	AASHTO M 85
Portland blast-furnace slag cement (Type IS)	AASHTO M 240
Portland-pozzolan cement (Type IP)	AASHTO M 240
Portland-limestone cement (Type IL)	AASHTO M 240

Use Type I, Type IL, or Type IS cement unless otherwise specified. Do not mix different types of cement.

Provide suitable means for storing and protecting the cement against dampness. The Engineer will reject cement that has become partially set or that contains lumps of caked cement.

Ensure that the temperature of the cement at the time of delivery to the mixer does not exceed 160 °F.

Do not use cement containing air-entraining materials.

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903.01 Fine Aggregate for Concrete

For concrete provide aggregate conforming to AASHTO M 6, with the following exceptions and additions:

1. The option regarding alternate freeze-thaw tests for soundness is waived.

2. The fine aggregate shall be washed in the processing operations.

3. Process fine aggregate, manufactured from limestone or dolomite, from material that has been scalped to remove quarry fines and that has a percentage of wear, as determined in accordance with AASHTO T 96, of not greater than 40. The fine aggregate, when subjected to five cycles of Sodium Soundness test, AASHTO T 104, shall have a weighted loss of not more than 10%.

4. The amount of deleterious substances shall not exceed the limits specified in Table 903.01-1.

Table 903.01-1: Limits of Deleterious Substances in Fine Aggregate for Concrete

Substance	Maximum Permissible Limits Percent by Weight
Clay Lumps	0.5
Coal and Lignite	0.5
Material Passing the No. 200 Sieve [(1)]	3.0
Other deleterious substances (such as shale, alkali, mica, coated/grains, soft and flaky particles) [(1) (2)]	3.0

[(1)] If the fine aggregate is manufactured from limestone or dolomite and if material finer than the No. 200 sieve consists of the dust of fracture, essentially free from clay or shale, this limit may be increased to 5%.

[(2)] Determine other organic impurities according to AASHTO T 267.

5. Provide fine aggregate that is well graded from coarse to fine within the limits specified in Table 903.01-2.

Table 903.01-2: Gradation Requirements for Fine Aggregate

Sieve Size	Total Percent Passing by Weight
3/8 inch	100
No. 4	95-100
No. 16	50-90
No. 50	5-30
No. 100	0-10
No. 200 (1)	0-3

(1) If the fine aggregate is manufactured from limestone or dolomite and if material finer than the No. 200 sieve consists of the dust of fracture, essentially free from clay or shale, this limit may be increased to 5%.

6. For use in flowable mortar, provide fine aggregate meeting the above requirements, except the gradation shall be as specified in Table 903.01-3.

Table 903.01-3: Gradation Requirements for Fine Aggregate used in Flowable Mortar

Sieve Size	Total Percent Passing by Weight
1/2 inch	100
No. 200	0-20

903.02 Fine Aggregate for Mortar

Provide mortar sand that conforms to AASHTO M 45 and that is uniformly graded from coarse to fine within the limits specified in Table 903.02-1.

Table 903.02-1: Gradation Requirements for Mortar Sand

Sieve Size	Total Percent Passing by Weight
No. 8	100
No. 50	15-40
No. 100	0-10
No. 200	0-5

903.03 Coarse Aggregate for Concrete

For any type or class of Portland cement concrete, provide coarse aggregate consisting of crushed stone, crushed slag, or crushed or uncrushed gravel, unless otherwise specified.

For Portland cement concrete base and pavement, furnish coarse aggregate in two sizes: Size No. 4 and Size No. 67, graded as specified in **903.22**. Manufacture the two sizes, within the specified limits, so as to produce Size No. 467, in accordance with **903.22**, when combined in the proper proportions at the batching plant, or a size No. 467, manufactured within the specified limits of **903.22**.

Coarse aggregate in Portland cement concrete pavements for finished riding surfaces of travel lanes including mainline pavements and ramps shall consist of Size No. 467. Ensure that either the Size No. 4 or Size No. 67 fractions meet **903.24**. Ramps using Class A modified concrete or any riding surface travel lane consisting of Size No. 57 shall meet **903.24**.

Coarse aggregate in Portland cement concrete bridge decks on interstates and four or more lane highways consisting of Size No. 57 shall meet **903.24**.

The coarse aggregates for travel lanes and bridge decks shall be crushed and consist of stone, slag, gravel, quartzite, gneiss, or combination thereof with a combined absorption of plus 4 material not to exceed 4%. Do not use uncrushed gravel, pea gravel, or any other uncrushed particles. Crushed gravel, if used, shall consist of siliceous washed particles after processing, of which at least 70% by count of the material retained on the No. 4 sieve contains a minimum of two fractured faces. One face shall be fractured for the approximate average diameter or thickness of the particle. Crushed stone used as a surface aggregate shall meet **903.24**.

For other uses of concrete, provide coarse aggregate of the sizes specified in Table 903.03-1, or as otherwise shown or directed.

Table 903.03-1: Coarse Aggregate Sizes

Application	Coarse Aggregate Size [1]
Structural concrete	No. 57
Prestressed concrete	No. 57 or 67
Precast concrete	Any size fraction
Concrete curbing placed by machine-extrusion methods	No. 7, 57, 67, or 78
Cement treated permeable base [2]	No. 57

[1] Gradation shall conform to **903.22**.

[2] Aggregate shall meet the quality requirements specified below.

The coarse aggregates shall otherwise conform to the requirements of AASHTO M 80, with the following exceptions and additions:

A. Deleterious Substances

The amount of deleterious substances shall not exceed the limits specified in Table 903.03-2.

Table 903.03-2: Limits of Deleterious Substances in Coarse Aggregate for Concrete

Substance	Maximum Percent by Weight
Soft or non-durable fragments (fragments that are structurally weak such as shale, soft sandstone, limonite concretions, gypsum, weathered schist, or cemented gravel), and organic impurities as determined by AASHTO T 267 (1)	3
Coal and lignite (1)	1
Clay lumps (1)	0.25
Material passing the No. 200 sieve (1) (2)	1
Thin or elongated pieces (length greater than 5 times average thickness)	10
Other local deleterious substances (1)	1

(1) The sum of the percentages of these materials (i.e., soft or non-durable fragments, coal and lignite, clay lumps, material passing the No. 200 sieve, and other local deleterious substances) shall not exceed 5.0.

(2) For crushed aggregate, if all the material finer than the No. 200 sieve, as determined in accordance with AASHTO T 11, consists of the dust of fracture, essentially free of clay or shale, this limit may be increased to 1.5.

B. Soundness

When the coarse aggregate is subjected to five alternations of the sodium sulfate soundness test in accordance with AASHTO T 104, the weighted percentage of loss shall not exceed 9. The Engineer may accept coarse aggregate failing to meet this requirement if it can be shown by evidence satisfactory to the Engineer that concrete of comparable proportions made from the same source has been exposed to weathering under conditions similar to those occurring at the site of the structure for a period of at least 10 years without appreciable disintegration.

The option regarding alternate freeze-thaw tests for soundness is waived.

The percentage of wear as determined in accordance with AASHTO T 96 shall not exceed 40.

903.04 Aggregate for Lean Concrete Base

Provide crushed limestone, crushed slag, or crushed or uncrushed gravel meeting the requirements of **903.05** for Type B, Grading D. The aggregate may be a "crusher or pit run" or may be sized into two or more sizes. If the material is "crusher or pit run," use methods that will prevent segregation during stockpiling and handling.

903.05 Aggregate for Mineral Aggregate Base and Surface Courses

Provide crushed stone, crushed slag, crushed or uncrushed gravel, or crushed or uncrushed chert that may be blended with crushed recycled concrete or screened reclaimed asphalt pavement (RAP), together with material such as manufactured sand or other fine materials that are either naturally contained or added as needed to conform to these Specifications.

Provide aggregate of Types A and B, as specified below.

A. Type A Aggregate

Provide hard, durable particles or fragments of stone, slag, gravel, or chert, and other finely divided mineral matter.

The Contractor may use recycled concrete aggregate or reclaimed asphalt pavement, at a maximum rate of 25% by weight, for Type A aggregate, provided the combined aggregate blend meets all the requirements specified below. Crush and screen the recycled concrete and asphalt to produce a uniform stockpile before blending it with the virgin material. Keep the recycled stockpiles free of bricks, steel, wood, and all other deleterious materials.

Provide individual or blended materials meeting the following requirements:

1. **Crushed Stone.** Provide stone free of silt and clay and having a coarse aggregate portion (retained on the No. 4 sieve) that conforms to the requirements specified in Table 903.05-1.

Table 903.05-1: Quality Requirements for Type A Aggregate

Aggregate Property	Test Method	Maximum Percent
Percentage of Wear	AASHTO T 96	50
Sodium Sulfate Soundness Loss (5 cycles)	AASHTO T 104	15

2. Crushed Slag. Provide material that:

a. Is free of silt and clay,
b. Meets the quality requirements in Table 903.05-1,
c. Is reasonably uniform in density, and
d. Has a dry-rodded weight of at least 70 pounds per cubic foot.

3. Gravel and Chert. Screen gravel and chert. All oversize material may be crushed and fed uniformly back over the screen. The coarse aggregate portion shall conform to the quality requirements specified in Table 903.05-1. The portion of the material passing the No. 40 sieve shall be non-plastic, or shall have a liquid limit of not greater than 30 and a plasticity index of not more than eight.

If fine aggregate, coarse aggregate, or binder, in addition to that present in the base material, is necessary to meet the gradation or density requirements or to ensure satisfactory bonding of the material, blend such material uniformly with the base course material at the mixing plant by a mechanical feeder to maintain a uniform flow on the belt to the mixer. Do not blend materials on the stockpiles or in the pits using a bulldozer, clamshell, dragline, or similar equipment.

The composite gradation of Type A aggregate shall be the grading specified in the Contract or shown on the Plans, and shall conform to the limits specified in Table 903.05-2.

B. Type B Aggregate

For Provide crushed or uncrushed gravel, crushed or uncrushed chert, crushed stone or crushed slag, and other finely divided particles.

The Contractor may use recycled concrete aggregate or reclaimed asphalt pavement, at a maximum rate of 30% by weight, for Type B

aggregate, provided the combined aggregate blend meets all the requirements specified below. Crush and screen recycled concrete and asphalt to produce a uniform stockpile before blending it with the virgin material. Keep the recycled stockpiles free of bricks, steel, wood, and all other deleterious materials.

Provide Type B aggregate meeting the same quality requirements as specified in **903.05.A** for Type A aggregate, with the following exceptions:

1. The sodium sulfate soundness loss shall not exceed 20.

2. Screen Type B aggregate. Oversize materials may be wasted or crushed and returned over the screen and uniformly blended with the other material.

3. Do not use material having a clay content greater than 12%, as determined by hydrometer analysis performed in accordance with AASHTO T 88. The Contractor may use material having a clay content not exceeding 12% if a plasticity index-fines product does not exceed 3 when calculated by the following formula:

$$\frac{\%\ \text{Passing No. 40 sieve} \times \text{P. I. of Minus No. 40 Material}}{100}$$

If an excess of binder occurs, uniformly incorporate crushed stone, crushed slag, gravel, chert, sand, or other approved granular materials in such proportions, not to exceed 20% of the total mix, as directed by the Engineer.

If the quantity of binder is insufficient to bond the base or surface course properly, uniformly incorporate additional binder of approved quality, in an amount not to exceed 15% of the total mix, as directed by the Engineer.

Do not use material requiring the addition of coarse aggregate or binder in excess of the above limits, unless otherwise shown on the Plans or specified in the Contract.

The Contractor may blend additional material, if required, either at the screening or mixing plant or on the road. If blending is done at the plant, use mechanical feeders that will maintain a uniform flow of the

materials on the conveyor belt to the mixer or screening plant. If blending is done on the road, spread the two or more materials in uniform layers, and blend using a mechanical mixer. Do not blend materials on the stockpile or in the pit using a bulldozer, clamshell, or similar equipment.

When combinations of materials for Type B aggregate for mineral aggregate base and surface courses, such as creek gravel and chert, bank gravel and chert, crushed stone and chert, crushed slag and chert, are permitted, the Department will designate these combinations on the Plans or in the Contract, and the pertinent requirements of this Specification for quality, blending of materials, and gradation shall apply.

The composite gradation of Type B aggregate shall be the grading shown on the Plans or specified in the Contract, and shall conform to the limits specified in Table 903.05-2.

Table 903.05-2: Grading Table for Type A and Type B Aggregate for Mineral Aggregate Base and Surface Courses

Sieve Size	Total Percent by Weight, Passing Sieves				
	Grading A	**Grading B**	**Grading C**	**Grading D**	**Grading E**
2-1/2 inch	100	--	--	--	--
2 inch	95-100	100	--	--	--
1-1/2 inch	--	95-100	100	100	--
1 inch	--	--	90-100	85-100	100
3/4 inch	--	65-95	--	60-95	90-100
3/8 inch	35-65	--	45-74	50-80	65-100
No. 4	--	35-55	30-55	40-65	--
No. 16	--	15-45	--	20-40 (1)	--
No. 100	0-10	4-15	4-15	9-18 (2)	5-15

(1) For gravel and chert bases containing clay, the range is 20-43.

(2) For gravel and chert bases containing clay, the range is 7-18.

903.06 Aggregate for Plant Mix Base and Leveling Courses (Hot Mix)

For plant mix base and leveling courses, provide coarse aggregate, fine aggregate, and mineral filler when required.

If at any time the sources of materials are changed, prepare and submit a new mix design as specified in **407.03**.

A. Coarse Aggregate (retained on a No. 4 sieve)

Provide crushed stone, crushed granite, crushed gravel, crushed slag, or a combination of these materials. This material shall conform to the quality requirements of ASTM D692, except that the sodium sulfate soundness loss shall not exceed 9%, and the aggregate shall contain no more than 5% soft or nondurable particles.

Crushed gravel shall consist of siliceous particles processed from washed material. At least 70% by count of the gravel retained on the No. 4 sieve shall have a minimum of two fractured faces, one of which must be fractured for the approximate average diameter or thickness of the particle. Do not add pea gravel or uncrushed particles.

For virgin coarse aggregate for Grading A, ACRL, and AS mixes, use crushed stone, crushed slag, or a combination of these materials.

The absorption of combined aggregate passing the 3/4-inch sieve and retained on the No. 4 sieve, for use in Grading CW mixes, shall not exceed 5% when tested in accordance with AASHTO T 85.

B. Fine Aggregate (passing a No. 4 sieve)

Provide limestone fines, natural sand, sand manufactured from stone, gravel, or slag, or combinations of these materials, consisting of hard, tough grains free from injurious amounts of deleterious substances. When subjected to five cycles of the sodium sulfate soundness test, the material shall have a weighted loss of not more than 12%. Do not use fine aggregate or screenings containing calcium sulfate ($CaSO_4$/gypsum) if more than 5% of the material passing the No. 8 sieve is chemically composed of sulfur trioxide (SO_3).

In natural sand or sand manufactured from gravel, the percentage of material finer than No. 200 sieve shall not exceed 5%.

For use in Grading A and AS mixes, provide virgin fine aggregate consisting of crushed stone or crushed slag only, and store the material separately from the coarse aggregate.

Ensure that the amount of deleterious substances in natural sand does not exceed the limits specified in Table 903.06-1.

Table 903.06-1: Maximum Limits for Deleterious Substances in Natural Sand

Substance	Maximum Permissible Limits, Percent by Weight
Clay Lumps	0.5
Coal and Lignite	0.5
Other deleterious substances (such as shale, alkali, mica, coated grains, soft and flaky particles) and organic impurities as determined by AASHTO T 267	3.0

C. Combined Aggregate Grading

Provide the appropriate combination of coarse aggregate and fine aggregate to achieve the combined grading. Use a minimum of three sizes of aggregate for all mix designs except for C, CS, and CW mixes, which shall be designed from a minimum of two sizes of aggregate.

Establish a gradation for each aggregate used in the mix. Table 903.06-2 specifies the stockpile gradation tolerance on each sieve for each virgin aggregate component used in the mix.

Table 903.06-2: Stockpile Gradation Tolerance

Sieve Size	Gradation Tolerance
3/8 inch sieve and larger	± 10%
No. 4 sieve	± 7%
No. 8 sieve	± 5%
No. 30 sieve	± 4%
No. 200 sieve (coarse aggregate)	± 2%
No. 200 sieve (fine aggregate)	± 4%

When the coarse aggregate portion of Grading CW mix is crushed limestone, use no less than 20% and no more than 50% by weight natural sand, or sand manufactured from slag or other approved non-skid aggregate. When the coarse aggregate portion is crushed gravel or crushed slag, between 15% and 40% by weight of the mineral aggregate shall be agricultural limestone or Size No. 10 limestone screenings.

The gradations of the coarse and fine fractions of aggregate shall be such that, when combined in proper proportions, the resultant mixture will meet one of the gradings specified in Tables 903.06-3 and 903.06-4.

Table 903.06-3: Hot Plant Mix Base Course Mixture Design Range of Gradations

Sieve Size	Total Percent Passing, by Weight			
	Grading A	Grading AS	Grading ACRL	Grading B
2 inch	100	100	100	100
1-1/2 inches	81-100	75-100	80-93	95-100
3/4 inch	50-71	55-80	60-75	70-85
3/8 inch	35-50	--	--	49-72
No. 4	24-36	7-11	12-16	34-51
No. 8	13-27	--	--	23-42
No. 30	7-17	--	--	11-22

Sieve Size	Total Percent Passing, by Weight			
	Grading A	Grading AS	Grading ACRL	Grading B
No. 50	--	--	--	9-14
No. 100	0-10	0-6	0-4	4-10
No. 200	0-4.5	0-4.5	0-3.5	2.5-6.5

Table 903.06-4: Hot Plant Mix Leveling Course Mixture Design Range of Gradations

Sieve Size	Total Per Cent Passing, by Weight				
	Grading BM	Grading BM2 (1)	Grading C	Grading CW	Grading CS
1-1/4 inch	--	100	--	--	--
1 inch	100	--	--	--	--
3/4 inch	85-100	81-93	100	100	--
3/8 inch	59-79	57-73	70-90	75-100	100
No. 4	42-61	40-56	39-66	--	89-94
No. 8	29-47	28-43	23-47	43-67	53-77
No. 30	13-27	13-25	10-27	23-47	23-42
No. 50	7-20	9-19	8-15	--	--
No. 100	4-10	6-10	4-8	4-10	9-18
No. 200	0-6.5	2.5-6.5	2.5-6.5	2.5-6.5	6-13.5

(1) When using natural sand as the fine aggregate, limit it to a maximum amount of 20% by weight of the mineral aggregate.

For asphalt treated permeable base as specified in **313**, meet the gradation requirements specified in Table 903.06-5.

Table 903.06-5: Gradation Requirements for Asphalt Treated Permeable Base

Sieve Size	Total Percent Passing by Weight
2 inch	100
1-1/2 inch	70-100
3/4 inch	55-80
No. 4	0-11
No. 100	0-4
No. 200	0-3

903.07 Reserved

903.08 Reserved

903.09 Reserved

903.10 Aggregate for Bituminous Plant Mix Surface Course (Cold Mix)

For cold bituminous plant mix, provide mix aggregate, consisting of crushed stone or crushed slag, meeting the quality requirements of ASTM D692. Crushed slag aggregate retained on the No. 4 sieve shall contain no more than 20% by weight of glassy particles.

The amount of material finer than the No. 200 sieve, as determined in accordance with AASHTO T 11, shall not exceed 1%. If all material finer than the No. 200 sieve consists of the dust of fracture, essentially free from clay or shale, this percentage may be increased to 1.5.

For leveling and surface course mixtures, provide mix aggregate meeting the gradation requirements specified in **903.22** for Size No. 68.

For key or choker aggregate, provide crushed stone, crushed slag, or crushed gravel meeting the gradation requirements specified in **903.22** for Size No. 8 and the same quality requirements as the mix aggregate.

903.11 Aggregate for Asphaltic Concrete Surface Courses (Hot Mix)

Provide aggregate, consisting of a combination of coarse and fine aggregate, and mineral filler when required or specified. Use a minimum of three sizes of aggregates for all mix designs.

If at any time the sources of materials are changed, provide a new mix design as specified in **407.03.C.2**.

A. Coarse Aggregate (retained on a No. 4 sieve)

Provide aggregate, consisting of crushed stone, crushed slag, crushed gravel, crushed granite, crushed quartzite, crushed gneiss, or combinations of these materials. The coarse aggregate shall meet the quality requirements of ASTM D692, with the following exceptions and additions:

1. Sodium sulfate soundness loss shall not exceed 9%.

2. Material retained on the No. 4 sieve shall contain a maximum of 20% elongated pieces (length greater than five times the average thickness).

3. Combined aggregate shall consist of siliceous particles processed from washed material, of which at least 70% by count of the material retained on the No. 4 sieve shall have a minimum of two fractured faces, one of which must be fractured for the approximate average diameter or thickness of the particle. Do not add pea gravel or uncrushed particles. The absorption of the crushed combined aggregate retained on the No. 4 sieve shall not exceed 5% when tested in accordance with AASHTO T 85.

4. Crushed slag coarse aggregate shall contain no more than 20% by weight of glassy particles.

B. Fine Aggregate (passing a No. 4 sieve)

Provide fine aggregate, consisting of natural sand, fines prepared from stone, slag, gravel, granite, quartzite, gneiss, or combinations of these materials. The fine aggregate shall meet the following requirements:

1. Fine aggregate shall consist of hard tough grains free from injurious amounts of clay, loam, or other deleterious substances.

2. When subjected to five cycles of sodium sulfate soundness test, the fine aggregate shall have a weighted loss of not more than 12%.

3. Manufactured sand shall have no more than 5% passing the No. 200 sieve when tested in accordance with AASHTO T 11.

4. Do not use fine aggregate or screenings containing calcium sulfate ($CaSO_4$/gypsum) if more than 5% of the material passing the No. 8 sieve is chemically composed of sulfur trioxide (SO_3).

5. Wash and grade natural sand so that not more than 5% will be retained on the No. 4 sieve.

6. For fine aggregate consisting of natural sand, the amount of material finer than a No. 200 sieve, as tested in accordance with AASHTO T 11, shall not exceed 4% by weight.

   The amount of deleterious substances in natural sand shall not exceed the limits specified in Table 903.11-1.

Table 903.11-1: Limits of Deleterious Substances in Natural Sand used in Hot Mix

Substance	Maximum Permissible Limits Percent by Weight
Clay Lumps	0.5
Coal and Lignite	0.5
Other deleterious substances (such as shale, alkali, mica, coated grains, soft and flaky particles) and organic impurities as determined by AASHTO T 267	3.0

7. When using agricultural limestone as a portion of the fine aggregate, manufacture it from sound, durable stone that is

crushed so that at least 85% will pass the No. 8 sieve and at least 50% will pass the No. 30 sieve.

C. Combined Aggregate Grading

Provide aggregate fractions sized, graded, and combined in proportions that will ensure the resulting composite blend will meet one of the gradation requirements specified in Table 903.11-2, together with the additional requirements pertaining to the constituents of the blend specified thereafter.

Establish a single value for each sieve size required in the mix for each virgin aggregate stockpile, with an allowable stockpile tolerance on each sieve as specified in Table **903.06-2**.

When using Gradings D or E for the surfacing of shoulders or for other non-traffic lane construction, the Contractor may modify the design with the Engineer's approval.

Table 903.11-2: Asphalt Concrete Surface Course Mixture Designation Design Range of Gradations

Sieve Size	Total Percent Passing by Weight				
	Grading D	Grading E	Grading TL	Grading TLD	Grading OGFC
3/4 inch	--	--	--	--	100
5/8 inch	100	100	--	--	--
1/2 inch	95-100	95-100	100	100	85-100
3/8 inch	80-93	80-93	100	90-100	55-75
No. 4	54-76	54-76	89-94	54-76	10-25
No. 8	35-57	35-57	53-77	35-57	5-10
No. 30	17-29	17-29	23-42	17-33	--
No. 50	10-18	10-18	--	10-18	--
No. 100	3-10	3-11	9-18	3-10	--
No. 200	0-6.5	0-8	6-14	4-7	2-4

1. **Grading D and TLD.** Use fine aggregate consisting of natural sand or sand manufactured from gravel, slag, or from crushed stone aggregate meeting the physical and chemical requirements specified in **903.24**. The use of carbonate rocks such as limestone and dolomite or other aggregates that tend to polish under traffic will not be permitted in the coarse aggregate and will be permitted only to the extent specified herein in the fine aggregate.

   When using limestone screenings or agricultural limestone, the maximum amount by weight of the mineral aggregate shall be 25% unless the material is shown to meet the same requirements for limestone as specified in Table **903.24-1** for Surface Mixtures. In no case shall the combined aggregate blend consist of less than 75% non-skid material. When using natural sand as fine aggregate, limit it to a maximum amount of 25% by weight of the mineral aggregate. The Contractor may substitute a maximum of 5% mineral filler meeting the requirements of **903.16** for an equal quantity of the limestone fines. If the mixture does not comply with the design criteria, provide another source of aggregate.

   When using gravel as the coarse aggregate for a 411 Grading D mix, use a minimum of 20% by weight limestone screenings, agricultural limestone, or mineral filler.

   Recycled Asphalt Pavement (RAP) milled from Department or other State Highway Agency projects shall be assumed to contain 75% non-skid material.

2. **Grading E.** When using Grading E as a surface for traffic lanes, 50% to 80% of the mineral aggregate shall be composed of crushed limestone, and the remaining 50% to 20% shall be natural sand, slag sand, sand manufactured from gravel or other approved non-skid aggregates, or any combination of these materials, with the following exceptions:

   a. The sand percentage on the Job Mix Formula (JMF) shall range from 20% to 50%. However, if needed to meet or improve the specified design criteria, the Contractor may alter the limestone and sand percentage by 5% from the percentage shown on the original JMF. If altering the aggregate percentages shown on the original JMF, submit a revision of the original design showing the altered percentages of aggregate.

b. When using Grading E for surfacing of shoulders or other non-traffic lane construction, the mineral aggregate may be composed entirely of limestone, including Size No. 10 (screenings) and manufactured sand, but in no case shall the mineral aggregate for this construction consist of less than 50% limestone.

c. Recycled Asphalt Pavement (RAP) milled from Department or other State Highway Agency projects shall be assumed to contain 75% non-skid material.

3. Grading OGFC. A minimum of 75% of the aggregate shall meet the requirements specified in **903.24** for Surface Mixtures (Non-Skid Aggregates). The coarse aggregate shall have at least 90% crushed aggregate with two fractured faces and 100% with one fractured face as determined in accordance with ASTM D5821. The coarse aggregate shall have a LA Abrasion value of less than 30% and a maximum absorption of 3.0%.

Recycled Asphalt Pavement (RAP) milled from Department or other State Highway Agency projects shall be assumed to contain 75% non-skid material.

4. Grading TL. A minimum of 75% of the aggregate shall meet the requirements specified in **903.24** for Surface Mixtures (Non-Skid Aggregates) for the appropriate traffic level. The mixture shall contain a maximum of 15% natural sands.

Recycled Asphalt Pavement (RAP) milled from Department or other State Highway Agency projects shall be assumed to contain 75% non-skid material.

903.12 Aggregate for Slurry Seal and Micro-Surface

A. Aggregate for Slurry Seal

A minimum of 50% of the aggregate shall be crushed slag, crushed granite, or crushed stone (crushed stone as specified in **903.24**), meeting the requirements of ASTM D692, except the gradation shall be as specified in Table 903.12-1. The aggregate shall have a minimum sand equivalent, as determined in accordance with AASHTO T 176, of 45.

Use a pug mill to mix blends of more than one aggregate source. Do not blend aggregates with a front end loader. Proportion the aggregate to produce a uniform gradation meeting the requirements specified in Table 903.12-1.

Table 903.12-1: Gradation Limits for Aggregate for Slurry Seal Based on Wash Gradation

Sieve	Design Master Range (Total Percent Passing)	Mixture Control Tolerances
3/8 inch	100	
No. 4	90-100	±6.0
No. 8	65-90	±5.0
No. 16	45-70	±5.0
No. 30	30-50	±4.0
No. 50	20-38	±4.0
No. 100	12-28	±3.0
No. 200	8-16	±3.0

B. Aggregate for Micro-Surface

A minimum of 50% of the aggregate shall be crushed slag, crushed granite, or crushed stone (crushed stone as specified in **903.24**) meeting the gradation limits specified in Table 903.12-2 and the physical properties of ASTM D692, except the percent of fractured pieces shall be 100. The aggregate shall have a minimum sand equivalent, as determined in accordance with AASHTO T 176, of 65. Polish-resistant aggregates will not be required for leveling courses, provided they will be covered with riding surface mixtures.

Use a pug mill to mix blends of more than one aggregate source. Do not blend aggregates with a front end loader. Proportion the aggregate to produce a uniform gradation meeting the requirements specified in Table 903.12-2.

Table 903.12-2: Gradation Limits for Aggregate for Micro-Surfacing Based on Wash Gradation

Sieve	Design Master Range (Total Percent Passing)	Mixture Control Tolerances
3/8 inch	100	
No. 4	70-98	±6.0
No. 8	45-70	±5.0
No. 16	28-50	±5.0
No. 30	19-34	±4.0
No. 50	12-25	±4.0
No. 100	7-18	±2.0
No. 200	4-15	±2.0

903.13 Aggregate for Bituminous Seal Coat

Provide aggregate consisting of crushed stone, crushed slag, or crushed gravel, meeting the quality requirements of ASTM D692, except that at least 50% by count of crushed gravel aggregates shall have at least one fractured face. Crushed slag aggregate retained on the No. 4 sieve shall contain no more than 20% by weight of glassy particles. Provide aggregates meeting the requirements of **903.24**.

The amount of material finer than the No. 200 sieve shall not exceed 1%. If all material finer than the No. 200 sieve consists of the dust of fracture, essentially free from clay or shale, the percentage may be increased to 1.5.

Use aggregate meeting the gradation requirements in **903.22** for the size identified on the Plans and in accordance with Table **405.06-1**.

903.14 Aggregate for Double Bituminous Surface Treatment

Provide aggregate meeting **903.13**. In the mat, use aggregate meeting the gradation requirements specified for Size No. 7 in **903.22**. In the seal, use aggregate meeting the gradation requirements specified for Size No. 8 in **903.22**. Ensure that at least 90% of the aggregate particles retained on the No. 4 sieve have one or more fractured faces fractured for the approximate average diameter or thickness of the particle.

903.15 Aggregate for Aggregate-Cement Base Course

Provide coarse aggregate, composed of sound, tough, durable fragments of crushed stone, crushed slag, crushed or uncrushed gravel, or crushed or uncrushed chert, which may be blended with crushed recycled concrete or screened reclaimed asphalt pavement (RAP), and fine aggregate composed of natural or manufactured sand, and silt-clay or other finely divided mineral matter.

Provide gravel or chert aggregate that is screened and of such gradation that 100% will pass a 1-1/2 inch sieve, not more than 75% will pass the No. 4 sieve, and not less than 5% nor more than 15% will pass the No. 200 sieve. The fraction passing the No. 40 sieve shall have liquid limit not greater than 35, and a plasticity index not greater than 10. Provide crushed stone or slag aggregate that is sized and proportioned to meet the gradation requirements specified in **903.05** for Grading D. Blend materials, if required, at the screening plant or at the stationary mixing plant.

The Contractor may use recycled concrete aggregate or reclaimed asphalt pavement (RAP), at a maximum rate of 25% by weight, provided the combined aggregate blend meets all the requirements specified above. Crush and screen the recycled concrete and/or asphalt to produce a uniform stockpile before blending it with the virgin material. Keep the recycled stockpiles free of bricks, steel, wood, and all other deleterious materials. The virgin and recycled material blend shall meet the quality requirements specified in Table **903.05-1**.

Ensure that the combined total of shale, organic material, and other unwanted substances does not exceed 5% by weight.

903.16 Mineral Filler

Provide mineral filler conforming to AASHTO M 17, except that the mineral filler shall be non-plastic.

903.17 Aggregate for Underdrains

Provide crushed stone, crushed slag, or washed gravel meeting the quality requirements of ASTM D692 and the gradation requirements specified for Size 6, 7, 8, 57, or 78 in **903.22**.

903.18 Aggregate for Sand-Asphalt Surface Course

Provide aggregate, consisting of natural sand, crushed siliceous material, or a combination of these materials, meeting the quality requirements of ASTM D1073. For natural sand, the percentage of material finer than the No. 200 sieve shall not exceed 5.

The natural sand or combination of these materials shall meet the gradation requirements specified in Table 903.18-1.

Table 903.18-1: Gradation Requirements for Aggregate for Sand-Asphalt Surface Course

Sieve Size	Total Percent Passing by Weight
No. 4	100
No. 8	95-100
No. 30	50-80
No. 50	30-60
No. 100	8-25
No. 200	2-10

903.19 Lightweight Aggregates for Structural Concrete

Provide lightweight aggregate conforming to AASHTO M 195, with the following additions:

1. Produce the lightweight aggregate by fusing raw shale, slate, or clay in a rotary kiln, to yield particles having a wear of not more than 40% when tested in accordance with AASHTO T 96.

2. The lightweight coarse aggregate shall conform to the gradation requirements for size 3/4 inch to No. 4, as shown in Table 1 of AASHTO M 195.

3. The absorption of the coarse aggregate shall not exceed 10% when tested in accordance with AASHTO T 85.

4. When the coarse aggregate is subjected to five alterations of the sodium sulfate soundness test in accordance with AASHTO T 104, the weighted percentage of loss shall not be more than 9.

5. Concrete with approximately 6% air content made from the aggregate shall have a minimum durability factor of 90% when tested in accordance with AASHTO T 161.

6. Use material listed on the Department's QPL.

903.20 Stockpiling Aggregates

Clean and grub sites for aggregate stockpiles before storing aggregates, and ensure the ground is firm, smooth, and well-drained. Maintain a cover of at least 3 inches of aggregate to prevent contamination by soil or foreign material. Build the stockpiles in layers not exceeding 4 feet in height, and have each layer completely in place before starting the next layer to prevent segregation. Deposit the material so as to prevent coning, except in the case of aggregate composed essentially of material finer than the No. 4 sieve and base material.

Do not dump, cast, or push material over the sides of stockpiles, except in the case of aggregate for base material and fine aggregate materials.

Unless otherwise approved, store aggregates from different sources or of different gradings, or that differ in specific gravity by more than 0.03, in separate stockpiles. To prevent the aggregates from mixing, either locate stockpiles of different types or sizes of aggregates far enough apart, or separate them with suitable walls or partitions.

When building stockpiles, only operate trucks or other equipment on a stockpile in a manner approved by the Engineer. Use stockpiling methods that will prevent both excessive degradation of the aggregate and contamination of the stockpile with foreign matter. The Engineer will determine excessive degradation by conducting sieve tests of samples taken from any portion of the stockpile over which equipment has operated; failure of such samples to meet all gradation requirements for the aggregate is cause for discontinuing such stockpiling procedure.

903.21 Test Methods

In stating requirements for most materials in Section **903**, reference has been made to AASHTO and ASTM Standard Specifications for materials. The current AASHTO or ASTM Standard Specification effective at the time of letting for a particular Contract shall be the governing specification. Those Specifications, in turn, include reference to the respective AASHTO and ASTM methods of sampling and testing. In a few instances, however,

properties of materials in Section **903** have been specified without reference to corresponding AASHTO and ASTM Standard Specifications. In such instances, the methods of sampling and testing specified in Table 903.21-1 will govern.

Table 903.21-1: Aggregate Sampling and Testing Methods

Test	Test Method
Unit Weight	AASHTO T 19
Percentage of Wear	AASHTO T 96
Soundness	AASHTO T 104
Liquid Limit	AASHTO T 89
Plastic Limit and Plasticity Index	AASHTO T 90
Sieve Analysis	AASHTO T 27
Hydrometer Analysis	AASHTO T 88
Material Passing No. 200 Sieve in Aggregate	AASHTO T 11
Ten Minute Boil Test	**407.03.E.2**
Resistance to Plastic Flow by Marshall Method	AASHTO T 245 (1)

(1) Use a mechanically operated hammer with a rotating base. The compaction hammer shall have a slanted, circular tamping face. The slant on the face shall be 1.6% + 0.0/-0.1.

903.22 Sizes of Coarse Aggregate

See AASHTO M 43.

Table 903.22-1: Standard Sizes of Processed Aggregate

Size	Nominal Size, Square Openings	Amounts Finer than Each Laboratory Sieve (Square Openings), Percent by Weight															
		4"	3-1/2"	3"	2-1/2"	2"	1-1/2"	1"	3/4"	1/2"	3/8"	No.4	No.8	No.16	No.50	No.100
1	3-1/2" - 1-1/2"	100	90-100	--	25-60	--	0-15	--	0-5	--	--	--	--	--	--	--
2	2-1/2" - 1-1/2"	--	--	100	90-100	35-70	0-15	--	0-5	--	--	--	--	--	--	--
24	2-1/2" - 3/4"	--	--	100	90-100	--	25-60	--	0-10	0-5	--	--	--	--	--	--
3	2"-1"	--	--	--	100	90-100	35-70	0-15	--	0-5	--	--	--	--	--	--
357	2" - No. 4	--	--	--	100	95-100	--	35-70	--	10-30	--	0-5	--	--	--	--
4	1-1/2" - 3/4"	--	--	--	--	100	90-100	20-55	0-15	--	0-5	--	--	--	--	--
467	1-1/2" - No. 4	--	--	--	--	100	95-100	--	35-70	--	10-30	0-5	--	--	--	--
5	1" - 1/2"	--	--	--	--	--	100	90-100	20-55	0-10	0-5	--	--	--	--	--
56	1" - 3/8"	--	--	--	--	--	100	90-100	40-85	10-40	0-15	0-5	--	--	--	--
57	1" - No. 4	--	--	--	--	--	100	95-100	--	25-60	--	0-10	0-5	--	--	--
6	3/4" - 3/8"	--	--	--	--	--	--	100	90- 100	20-55	0-15	0- 5	--	--	--	--
67	3/4" - No. 4	--	--	--	--	--	--	100	90-100	--	20-55	0-10	0-5	--	--	--
68	3/4" - No. 8	--	--	--	--	--	--	100	90-100	--	30-65	5-25	0-10	0-5	--	--
7	1/2" - No. 4	--	--	--	--	--	--	--	100	90-100	40-70	0-15	0-5	--	--	--
78	1/2" - No. 8	--	--	--	--	--	--	--	100	90-100	40-75	5-25	0-10	0-5	--	--
8	3/8" - No. 8	--	--	--	--	--	--	--	--	100	85-100	10-30	0-10	0-5	--	--
89	3/8" - No. 16	--	--	--	--	--	--	--	--	100	90-100	20-55	5-30	0-10	0-5	--
9	No. 4 - No. 16	--	--	--	--	--	--	--	--	--	100	85-100	10-40	0-10	0-5	--
10	No. 4 – 0 (1)	--	--	--	--	--	--	--	--	--	100	85-100	--	--	--	10-30

(1) Screenings

903.23 Reserved

903.24 Aggregates for Riding Surfaces (Polish-Resistant Aggregates)

Provide coarse aggregate consisting of crushed gravel, crushed granite, crushed slag, crushed quartzite, or crushed gneiss meeting the BPN requirements of the table below. The Contractor may use other crushed aggregate provided it has the chemical, physical, and performance characteristics specified in Table 903.24-1.

Table 903.24-1: Quality Requirements for Type I, II, III, and IV Aggregate

Aggregate Property	Test Method	Type I (all roads)	Type II (all roads)	Type III (15,000 ADT max, excluding Interstates)	Type IV (5,000 ADT max)
Silica Dioxide Content, % min	ASTM C25	40%	30%	20%	10%
Calcium Carbonate Content, % max		32%	--	--	--
Acid Insoluble Residue, % min	ASTM D3042	50%	35%	25%	--
British Pendulum Number,(1) min	AASHTO T 278 AASHTO T 279	30	30	25	22

(1) After 9 hours of accelerated polishing using the British Wheel in accordance with AASHTO T 279

In addition to the requirements specified in Table 903.24-1, Type II, III, and IV aggregates shall have met the preapproval process of the Division of Materials and Tests. All aggregate types must also maintain a satisfactory level of field performance to remain an approved source.

Process and stockpile the material as an independent and separate operation. The Engineer will sample and test each stockpile for approval prior to use.

SECTION 904 – BITUMINOUS MATERIALS

904.01 Asphalt Cements 948
904.02 Reserved 950
904.03 Emulsified Asphalts 950

904.01 Asphalt Cements

Only obtain asphalt cement for use on Department projects from Certified Asphalt Suppliers that have an approved Quality Control Plan in accordance with the Department's Standard Operating Procedures.

Asphalt cement shall conform to AASHTO M 320 and Department procedures.

Instead of PG 64-22, the Contractor may use asphalt cement graded to PG 67-22. PG 67-22 shall conform to the requirements of AASHTO M 320 when the applicable tests are conducted at 67 °C and -12 °C, and the dynamic shear of the rolling thin film, pressure aged vessel sample is tested at 26.5 °C.

To modify the asphalt, properly blend styrene butadiene (SB), styrene butadiene styrene (SBS), or styrene butadiene rubber (SBR) to a PG 64-22 or PG 67-22 base asphalt.

In addition to the above requirements, the PG 70-22, PG 76-22, and 82-22 shall meet the requirements specified in Table 904.01-1.

Table 904.01-1: Requirements for Asphalt Cement

Property	PG 70-22	PG 76-22	PG 82-22
Ring & Ball Softening Point, degrees F, minimum	128	135	150
Elastic Recovery by means of Ductilometer, % minimum	45	65	70

A. Test Procedures

1. **Elastic Recovery by means of a Ductilometer.** Test in accordance with AASHTO T 301 at 77 °F.

2. **Screen Test.** Pour a 1,000-gram sample heated to 275 °F through a No. 10 sieve. Ensure no lumps or particles are retained on the sieve.

3. **Viscometer Test.** In addition to the above, all hot mix asphalt mix plants using modified liquid asphalt products shall have a rotational viscometer, meeting ASTM D4402 requirements, with a thermostatically controlled cell. The mix producer shall run a minimum of one test per week on samples taken from the Contractor's storage tank. Viscosity values shall be in the ranges specified in Table 904.01-2 when tested at 275 °F.

Table 904.01-2: Asphalt Cement Viscosity Requirements

Property	PG 70-22	PG 76-22	PG 82-22
Viscosity Range (centipoise)	650-3,000	1,000-3,000	2,000-4,000 (1)

(1) Store PG82-22 at proper temperatures to maintain pumpability.

B. Materials Certification

Furnish a certification to the Engineer on each project stating that the asphalt cement provided meets the Department's specification. Ensure that quality control and compliance testing are completed in accordance with the asphalt supplier's approved quality control plan and Department procedures.

Where blending or modification occurs after the material has left the storage tanks, the supplier shall conduct a complete series of tests on a sample taken on the first day's production and biweekly thereafter for each grade being produced. Brookfield viscosity and DSR original tests shall be performed daily at the point of blending or modification. The DSR value $G^*/\sin\delta$ shall be ≥1.0 kPa at the high PG grade temperature (i.e., 158 °F for PG 70-22).

In addition, the producer shall provide a temperature-viscosity curve with a recommended mixing temperature range. In order to develop a temperature-viscosity curve, it may be necessary to run the viscosity test at a higher temperature, based on the softening point of the modified asphalt cement.

904.02 Reserved

904.03 Emulsified Asphalts

Provide emulsified asphalts meeting the test requirements specified in Table 904.03-1.

Table 904.03-1(a): Test Requirements for Emulsified Asphalt

Practices	AASHTO Test Method	CAE-P	CSS-1	CSS-1H	SS-1H	TST-1P	CQS-1H
Saybolt-Furol Viscosity @ 77 °F, seconds	T59	10-50	20-100	20-100	20-100	10-75	20-100
Saybolt-Furol Viscosity @ 122 °F, seconds	T59	n/a	n/a	n/a	n/a	n/a	n/a
Storage Stability Test, 24- h, %	T59	1 Max	1 Max	1 Max	1 Max	n/a	n/a
5-day Settlement, %	T59	n/a	n/a	n/a	n/a	n/a	n/a
Particle Charge	T59	Positive	Positive	Positive	n/a	n/a	Positive
Sieve Test, %	T59	0.1 Max	0.1 Max	0.1 Max	0.1 Max	0.1 Max	0.1 Max
Residue by	T59	Distillation	Distillation	Distillation	Distillation	Distillation(1)	Distillation
Residue, %	T59	n/a	57 Min	57 Min	57 Min	55-60	62 Min
Demulsibility, %	T59	n/a	n/a	n/a	n/a	n/a	n/a
Distillate, %	T59	55 Max	n/a	n/a	n/a	n/a	n/a
Oil Test, %	T59	12 Max	n/a	n/a	n/a	n/a	n/a
Stone Coating	T59	n/a	n/a	n/a	n/a	n/a	n/a
Float Test, seconds	T50	n/a	n/a	n/a	n/a	n/a	n/a
Penetration	T49	300 Min	100-250	40-90	40-90	75-150	40-90
Elastic Recovery, % (2)	T301	n/a	n/a	n/a	n/a	25 Min	n/a
Ductility @ 77 °F, cm	T51	40 Min	40 Min	40 Min	40 Min	n/a	40 Min
Ductility @ 40 °F, cm	T51	n/a	n/a	n/a	n/a	10-35	n/a
R&B Softening	T53	n/a	n/a	n/a	n/a	n/a	n/a

Practices	AASHTO Test Method	CAE-P	CSS-1	CSS-1H	SS-1H	TST-1P	CQS-1H
Point, °F							
Original G*/sind @ 82 °C	T315	n/a	n/a	n/a	n/a	n/a	n/a

(1) Distill at 400°F

(2) Straight-sided mold, 20-cm elongation, 5 min hold, 25 °C

Table 904.03-1(b): Test Requirements for Emulsified Asphalt

Practices	AASHTO Test Method	CQS-1HP	SS-1	AEP	CRS-2	AE3
Saybolt-Furol Viscosity @ 77 °F, seconds	T59	20-100	20-100	10-50	n/a	n/a
Saybolt-Furol Viscosity @ 122 °F, seconds	T59	n/a	n/a	n/a	100-400	50 Min
Storage Stability Test, 24- h, %	T59	n/a	1 Max	n/a	1 Max	n/a
5-day Settlement, %	T59	n/a	n/a	5 Max	n/a	5 Max
Particle Charge	T59	Positive	n/a	n/a	Positive	n/a
Sieve Test, %	T59	0.1 Max	0.1 Max	0.1 Max	0.1 Max	n/a
Residue by	T59	Distillation[1]	Distillation	Distillation	Distillation	Distillation
Residue, %	T59	62 Min	57 Min	n/a	65 Min	n/a
Demulsibility, %	T59	n/a	n/a	n/a	40 Min	n/a
Distillate, %	T59	n/a	n/a	55 Max	n/a	30 Max
Oil Test, %	T59	n/a	n/a	12.0 Max	3.0 Max	6.0 Max
Stone Coating	T59	n/a	n/a	n/a	n/a	90 Min
Float Test, seconds	T50	n/a	n/a	20 Min	n/a	200 Min
Penetration	T49	40-90	100-200	n/a	100-250	n/a
Elastic Recovery, % [2]	T301	n/a	n/a	n/a	n/a	n/a
Ductility @ 77 °F, cm	T51	70 Min	40 Min	n/a	40 Min	n/a
Ductility @ 40 °F, cm	T51	n/a	n/a	n/a	n/a	n/a
R&B Softening Point, °F	T53	135 Min	n/a	n/a	n/a	n/a
Original G*/sind @ 82 °C	T315	n/a	n/a	n/a	n/a	n/a

[1] Distill at 350 °F

[2] Straight-sided mold, 20-cm elongation, 5 min hold, 25 °C

Table 904.03-1(c): Test Requirements for Emulsified Asphalt

Practices	AASHTO Test Method	CRS-2P	RS-2	RS-1	TTT-1	TTT-2
Saybolt-Furol Viscosity @ 77 °F, seconds	T59	n/a	n/a	20-100	30 Min	n/a
Saybolt-Furol Viscosity @ 122 °F, seconds	T59	100-400	75-400	n/a	n/a	15-100
Storage Stability Test, 24- h, %	T59	1 Max	1 Max	1 Max	1 Max	1 Max
5-day Settlement, %	T59	n/a	n/a	n/a	5 Max	n/a
Particle Charge	T59	Positive	n/a	n/a	n/a	Positive
Sieve Test, %	T59	0.1 Max	0.1 Max	0.1 Max	0.1 Max	0.1 Max
Residue by	T59	*Evaporation*	Distillation	Distillation	Distillation	Distillation [(1)]
Residue, %	T59	65 Min	63 Min	55 Min	40 Min	58 Min
Demulsibility, %	T59	40 Min	60 Min	60 Min	n/a	n/a
Distillate, %	T59	n/a	n/a	n/a	n/a	n/a
Oil Test, %	T59	n/a	n/a	n/a	n/a	n/a
Stone Coating	T59	n/a	n/a	n/a	n/a	n/a
Float Test, seconds	T50	n/a	n/a	n/a	n/a	n/a
Penetration	T49	75-175	100-200	100-200	5-15	40-90
Elastic Recovery, % [(2)]	T301	50 Min	n/a	n/a	n/a	n/a
Ductility @ 77 °F, cm	T51	40 Min	40 Min	40 Min	40 Min	n/a
Ductility @ 40 °F, cm	T51	n/a	n/a	n/a	n/a	n/a
R&B Softening Point, °F	T53	125 Min	n/a	n/a	60-75	n/a
Original G*/sind @ 82 °C	T315	n/a	n/a	n/a	1.0 Min	n/a

[(1)] Distill at 350 °F

[(2)] Straight-sided mold, 20-cm elongation, 5min hold, 25 °C

The producer may conduct a 24-hour (1% Max) storage stability test instead of the 5-day settlement test if the emulsions are to be used within 5 days.

Obtain emulsified asphalts for use on Department projects from Certified Emulsified Asphalt Suppliers that have an approved Quality Control Plan in accordance with the Department's Standard Operating Procedures.

All emulsified asphalts shall be homogeneous, and shall adhere firmly to the surface of the mineral aggregate. Failure of the emulsified asphalt to perform satisfactorily on the job is cause for rejection, regardless of its ability to pass laboratory tests.

Use the AE-3 of such stability that it will remain constant and uniform while being mixed with dry or approximately dry aggregate, and that will thoroughly and uniformly coat the entire surface of each fragment while being manipulated and incorporated into the Work. The emulsified asphalt after being incorporated into the Work shall show no signs of re-emulsifying.

When approved by the Engineer, the Contractor may substitute cationic emulsions for anionic emulsions.

Use latex, polymer, and other emulsifiers of styrene butadiene rubber (SBR) or natural latex when manufacturing CQS-1hp. Mill such emulsifiers into the asphalt cement so as to show no separation after mixing.

When using modified emulsions in micro-surface mixtures, the blended mixture when combined with aggregate and mineral filler shall be:

1. Capable of filling up to 1/2-inch wheel ruts in one pass;

2. Capable of field regulation of the setting time; and

3. Suitable for nighttime placement.

Combine the latex with the asphalt emulsion at the emulsion mill to produce a homogeneous mixture. Latex modified emulsions, upon standing undisturbed for a period of 24 hours, shall have a uniform color throughout, showing no color striations.

SECTION 905 – JOINT MATERIALS

905.01 Preformed Joint Fillers (Non-Extruding and Resilient Types) 956
905.02 Joint Mortar 956
905.03 Rubber Gaskets 957
905.04 Hemp or Oakum Gaskets 957
905.05 Joint Sealants 957

905.01 Preformed Joint Fillers (Non-Extruding and Resilient Types)

Provide preformed joint fillers of the bituminous type unless otherwise shown on the Plans. When designated, punch holes in preformed joint filler to admit the dowels.

A. Bituminous Type

Provide bituminous type preformed joint fillers conforming to AASHTO M 213.

B. Non-Bituminous Types

Provide non-bituminous types of preformed joint filler conforming to AASHTO M 153, Type I, II, or III, as specified.

Furnish the filler for each joint in a single piece for the full depth and width required for the joint unless otherwise directed by the Engineer. If the Engineer approves the use of more than one piece for a joint, fasten the abutting ends securely, and hold to shape by stapling or using other positive means of fastening satisfactory to the Engineer.

905.02 Joint Mortar

Provide pipe joint mortar consisting of one part Portland cement and two parts sand, adding water as necessary to obtain the required consistency. Use Portland cement conforming to the requirements of **901.01**, Type I, and sand conforming to the requirements of **903.02**. Obtain the Engineer's

approval of the water quality. Use mortar within 30 minutes after its preparation.

905.03 Rubber Gaskets

Provide gaskets conforming to ASTM C443.

905.04 Hemp or Oakum Gaskets

Provide gaskets of hemp or oakum packing for joint filler that are closely twisted, and of the size and type required for the pipe under construction. Gaskets shall be in one piece of sufficient length to pass around the pipe and lap.

905.05 Joint Sealants

A. Sealing Longitudinal Joints between Portland Cement and Asphaltic Concrete

To seal the longitudinal joint between Portland cement and asphaltic concrete, use hot-poured elastic type sealants that comply with the following requirements:

1. Use hot poured elastic type sealants conforming to ASTM D6690, with the following exceptions:

    a. The joint sealer shall be a mixture of virgin synthetic rubber, reclaimed rubber, or a combination of these materials with asphalt and plasticizers and tacifiers.

    b. Do not use ground cured rubber scrap.

    c. The sealer shall be free of foreign material and, when melted, free of lumps.

    Furnish the Engineer a certified statement from the manufacturer indicating compliance with the above composition.

2. The flow at 140 °F shall not exceed 0.4 inch in 5 hours. Ductility at 77 °F shall be not less than 16 inches, when tested in accordance with AASHTO T 51.

3. Furnish the Engineer a certified copy of the test results, showing the batch number and indicating that the material supplied conforms to the requirements of the specifications.

B. Sealing Longitudinal and Transverse Joints and Random Cracks in PCC Pavement

To seal longitudinal and transverse joints and random cracks in Portland cement concrete pavement, use one of the following materials, as shown on the Plans:

1. Hot poured elastic type sealant meeting the requirements of **905.05.A**.

2. Silicone sealant having a low modulus silicone that is specially manufactured to seal Portland cement concrete pavements joints. Furnish silicone sealant in a one part silicone formulation that is non-acid curing and meets the requirements specified in Table 905.05-1.

Table 905.05-1: Requirements for Silicone Sealants

Property	Test Method	Value
Flow	MIL S 8802	5 inches, maximum
Extrusion rate	MIL S 8802	90-250 grams per minute
Tack free time (1)	SAE-AMS-S-8802	35-75 minutes
Specific gravity	ASTM D792, Method A	1.010-1.515
Durometer hardness Shore A (1)	ASTM D2240	10-25
Joint movement and tensile stress at 150% elongation (1)	ASTM D 412, Die C	± 50% joint movement; 75 psi maximum tensile stress
Peel (Adhesion): Unprimed aluminum panel with aluminum screen (1)	MIL S 8802	20 pounds, minimum, with at least 75% cohesive failure

Property	Test Method	Value
Bond to concrete mortar concrete briquets air cured 7 days at 77 ± 3 °F [2]	AASHTO T 132	50 psi, minimum

[1] 7 day cure at 77 ± 3 °F and 45-55% relative humidity

[2] Determine the bond to concrete mortar by molding briquets in accordance with AASHTO T 132, sawed in half and bonded with a thin section of sealant. Test the briquets in accordance with AASHTO T 132. Dry briquets to constant weight in an oven at 212 ° ±40 °F.

If shown on the Plans, provide a backer rod (bond breaker) that is compatible with the sealant and will ensure no bond or reaction will occur between the rod and the sealant.

Use joint fillers and sealants selected from the Department's QPL. Certify that the product meets the applicable specifications and that the material is identical to that previously tested and placed on the QPL.

The Department reserves the right to perform any testing deemed necessary to ensure compliance with these Specifications.

SECTION 906 – DAMPPROOFING AND WATERPROOFING MATERIALS

906.01 General 960
906.02 Class I Dampproofing and Waterproofing 960
906.03 Class II Dampproofing and Waterproofing 960
906.04 Bridge Deck Sealants 961

906.01 General

This Section covers materials used in dampproofing and waterproofing concrete surfaces.

Provide the Class of waterproofing shown on the Plans or as otherwise specified or directed.

906.02 Class I Dampproofing and Waterproofing

Provide materials conforming to the following:

1. Asphalt seal for use below ground level: ASTM D 449, Type I

2. Asphalt seal for use above ground level: ASTM D 449, Type II or Type III, as specified

3. Bituminous fabric: ASTM D 173

906.03 Class II Dampproofing and Waterproofing

Provide materials conforming to the following:

1. Asphalt seal for use below ground level: ASTM D 449, Type I

2. Asphalt seal for use above ground level: ASTM D 449, Type II or Type III, as specified

3. Bituminous fabric: ASTM D 173

4. Plain asphalt plank: ASTM D 517, Type I

906.04 Bridge Deck Sealants

A. System A

1. Membrane. Provide a membrane laminate formed with suitably plasticized coal tar and reinforced with non-woven synthetic fibers or glass fibers. The membrane shall be a uniformly well-manufactured product, free from blemishes, discontinuities, and other defects. Furnish the membrane in rolls, having a width of 30 or 48 inches or other widths as approved by the Engineer. Ensure that the membrane conforms to the requirements specified in Table 906.04-1.

Table 906.04-1: Requirements for Membrane (System A)

Property	Test Method	Value
Thickness	-	70 ± 5 mils
Pliability 180-degree Bend over 1/4-inch mandrel at -25 °F	ASTM D146	No cracks
Softening Point (minimum)	ASTM D36 (R & B)	230 °F

2. Mastic. Use a cold-applied type mastic, recommended by the membrane manufacturer, that is compatible with the membrane.

B. System B

1. Membrane. Provide a laminate of rubberized asphalt, reinforced with synthetic fibers or mesh. The membrane shall be a uniformly well-manufactured product, free from blemishes, discontinuities, and other defects. Furnish membrane in rolls having a width of 36 inches or other widths as approved by the Engineer. Ensure that the membrane conforms to the requirements specified in Table 906.04-2.

Table 906.04-2: Requirements for Membrane (System B)

Property	Test Method	Value
Thickness (minimum	--	65 mils
Tensile strength (minimum)	ASTM D882	300 psi
Elongation at Break (minimum)	ASTM D882	150%
Pliability 180-degree Bend over 1/4-inch mandrel at -25 °F	ASTM D146	No cracks
Peel Adhesion, 7 days at 120 °F +7 days water immersion (minimum)	TT-S-00230 Modified	5 psi

2. Mastic. Use a cold-applied type mastic, recommended by the membrane manufacturer, that is compatible with the membrane.

Provide bridge deck sealants listed on the Department's QPL. Prior to approval and use of the materials for bridge deck sealant, submit to the Materials and Test Engineer a notarized certification by the formulator of these materials, stating that the materials proposed for use, or materials of identical formulation, have been tested and meet all the specified requirements. Include with this notarized certification a certified laboratory test report, containing numerical test data of all the specified requirements, for the materials, or materials of identical formulation, proposed for use, and a sample of the proposed materials for preliminary evaluation. The approval granted based on these certifications will remain in effect until such time that the formulation is changed or the Materials and Tests Engineer requires, at its discretion, requalification of the materials for use, in which event the qualifying procedure shall be repeated.

Submit a certification from the manufacturer of the materials with each subsequent shipment of materials. The certification shall identify the shipment by lot or batch number, state the quantity of material shipped, and state that the material is identical to a particular lot or batch number (designate) that the Department previously qualified for use.

The Department reserves the right to require samples of all materials to be submitted to the Laboratory for testing.

SECTION 907 – CONCRETE REINFORCEMENT

907.01 Bar Reinforcement for Concrete Structures 963
907.02 Dowel and Tie Bars 963
907.03 Welded Steel Wire Fabric 964
907.04 Prestressing Reinforcement Steel and Anchorages 964

907.01 Bar Reinforcement for Concrete Structures

Unless otherwise specified, for all steel reinforcement for concrete, provide billet steel bars conforming to the requirements of ASTM A615, Grade 60. Use standard CRSI hook details unless otherwise shown on the Plans. Provide epoxy-coated reinforcing steel that is listed on the Department's QPL and that conforms to ASTM D3963 and ASTM A775.

Package, in an air tight container, a representative 8-ounce sample of the coating material from each batch, identify it by batch number, and furnish to the Engineer. In addition, for repair of any damage incurred during shipment or installation, the fabricator initially shall furnish to the Project a repair kit containing a touch-up roller and 16 ounces of touch-up coating material with each shipment of epoxy coated reinforcing steel, with additional supplies being furnished as needed.

Provide metal chairs and supports coated with plastic, epoxy, or other approved material that is chemically and electrically inert in concrete. Provide plastic-coated tie wires for use with epoxy-coated reinforcing steel. Obtain the Engineer's approval of such tie wires before use.

907.02 Dowel and Tie Bars

Provide plain dowel bars conforming to ASTM A36 or A615. Use paint meeting the requirements of SSPC Paint Specification No. 15, Type 1 (red oxide paint) or SSPC Paint Specification No. 25. For plastic coated dowels, meet the coating requirements of AASHTO M 254. For epoxy coated dowels, meet the coating requirements of ASTM D3963.

Provide bond breakers, of the type recommended by the coating manufacturer, for all dowel bars except for Type A coated dowels conforming to AASHTO M 254.

Provide deformed tie bars conforming to ASTM A615.

907.03 Welded Wire Reinforcement

Provide welded wire reinforcement conforming to ASTM A1064. Refer to the Plans for gauges, spacing, and arrangement of wires and coating.

907.04 Prestressing Reinforcement Steel and Anchorages

Assign a lot number to all wire, strand, and bars, and tag them for identification purposes. Likewise, identify anchorage assemblies, and provide certification that the assemblies meet the Post-Tensioning Institute's *Acceptance Standards for Post-Tensioning Systems*.

Furnish a minimum of two samples from each lot or shipment received. Furnish additional samples as directed by the Engineer.

The Engineer will base acceptance of the steel on the results of physical tests conducted by the Department and a manufacturer's certification showing results of the required tests, including stress-strain curves representative of the lot to be used.

Provide wire that is free from injurious defects and that has a workmanlike finish with a smooth surface. The Engineer will reject material that shows injurious defects during or prior to its installation in the Work.

In addition to the above, the prestressing steel and anchorages for post-tensioned tendons shall comply with the following requirements:

A. Seven-Wire Strand for Prestressed Concrete

Provide strand conforming to ASTM A416 for the Grade specified. The strand manufacturer shall certify that the strand has been tested and will bond to concrete of normal strength and consistency in conformance with the prediction equations for transfer and development lengths given in ACI/AASHTO Specifications.

B. Parallel Wire Assemblies for Post-Tensioning

Provide assemblies consisting of parallel wires of the number and size shown on the Plans. Wires shall be high-tensile, hard-drawn, stress-relieved, and uncoated, and shall conform to ASTM A421.

C. Bars for Post-Tensioning

Stress-relieve high tensile strength alloy bars, and then cold-stretch to a minimum of 130,000 pounds per square inch. After cold-stretching, the bars shall meet the physical properties specified in Table 907.04-1.

Table 907.04-1: Physical Properties for Post-Tensioning Bars

Property	Value
Minimum ultimate tensile strength	145,000 psi
Minimum yield strength, measured by the 0.7% extension-under-load method	130,000 psi
Minimum modulus of elasticity	25,000,000 psi
Minimum elongation in 20 bar diameters after rupture	4%
Diameter tolerance	+0.03 inch/-0.01 inch

D. Anchorages for Post-Tensioned Tendons

1. **For Bars.** Use wedge type anchorages that will develop the minimum ultimate stress specified for the nominal bar area. Wedge type anchorages shall bear against anchorage plates fabricated of hot rolled steel of type and quality approved by the Engineer.

2. **For Parallel Wire Assemblies.** Unless otherwise specified, use wedge type anchorages of the sandwich plate or conical type, that are capable of developing the ultimate strength of the total number of wires anchored. Embed conical type anchorages within the ends of the concrete members unless otherwise specified. Generally, anchorages shall bear against embedded grids of reinforcing steel approved by the Engineer.

3. Alternate Types. The Contractor may use alternate anchorage types conforming to the general physical requirements specified above for wedge type anchorages if approved by the Engineer.

Before obtaining the Engineer's approval, demonstrate alternate type anchorages are capable of withstanding at least 3,000,000 cycles of twice the maximum live load stress.

SECTION 908 – STRUCTURAL STEEL AND APPURTENANT MATERIALS

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908.01 Structural Steel

Unless otherwise specified, provide steel plate conforming to ASTM A709, Grade 50 or 50W, and bar stock and rolled shapes conforming to ASTM A709 Grade 50S.

908.02 Plate for Cold Working

Provide plate, that is to be bent or formed cold during fabrication, that conforms to ASTM A283, Grade C.

908.03 Permanent Steel Bridge Deck Forms

Fabricate permanent steel bridge deck forms and supports from steel conforming to ASTM A653 (SS Grades 33 through 80) and having a coating Class G 165 in accordance with ASTM A653.

908.04 High Strength Structural Bolts

Provide bolts, nuts, and washers that are manufactured in the United States, from steel smelted and manufactured in the United States, and that conform to the following requirements:

A. Specifications

Provide bolts, nuts, and washers that conform to the following requirements:

1. **Bolts.** ASTM A325 - High Strength Bolts for Structural Joints.

2. **Nuts.** ASTM A563 - Carbon and Alloy, heat treated Steel Nuts, Grades DH and DH3.

3. **Washers**

    a. ASTM F436 - Hardened Steel Washers.
    b. ASTM F959 - Compressible Washer Type Direct Tension Indicators for Use with High Strength Bolts.

B. Manufacturing

1. **Bolts.** Hardness for bolt diameters 1/2 to 1 inch inclusive shall be as specified in Table 908.04-1.

Table 908.04-1: Hardness Number

Bolt Size	Brinell		Rockwell C	
	Min	Max	Min	Max
1/2 to 1 inches	248	311	24	33

2. **Nuts.** Provide plain nuts of grades DH or DH3, and galvanized nuts of grade DH.

3. Marking. Mark all bolts, nuts, and washers in accordance with the appropriate AASHTO/ASTM Specifications.

C. Testing

Only provide high strength bolts, nuts, and washers that have been certified to have met the specified tests identified in their individual ASTM Specification designations, both as individual components, and as assemblies (bolts, nuts, and washers).

1. Bolts

a. Perform proof load tests, in accordance with ASTM F606 Method 1, at the minimum frequency of testing specified in ASTM A325 paragraph 9.2.4.

b. Perform wedge tests on full size bolts, in accordance with ASTM F606 paragraph 3.5, at the minimum frequency of testing specified in ASTM A325 paragraph 9.2.4.

2. Nuts. Perform proof load tests, in accordance with ASTM F606 paragraph 4.2, at the minimum frequency of testing specified in ASTM A563 paragraph 9.

3. Assemblies. The manufacturer or distributor shall perform rotational-capacity tests on all bolt, nut, and washer assemblies prior to shipping as specified in **602.17.E.1** and **602.17.E.2**.

Perform this testing for complete assemblies each day at the site of bolting in accordance with the following:

a. Except as modified herein, perform the rotational-capacity test in accordance with the requirements of ASTM A325.

b. Test each combination of bolt production lot, nut lot, and washer lot as an assembly. Where washers are not required by the installation procedures, do not include them in the lot identification.

c. Assign a rotational-capacity lot number to each combination of lots tested.

d. Test a minimum of two assemblies per rotational-capacity lot.

e. Assemble the bolt, nut, and washer assembly in a Skidmore-Wilhelm Calibrator or an acceptable equivalent device (note - this requirement supersedes the current ASTM A325 requirement that the test be performed in a steel joint). For short bolts that are too short to be assembled in the Skidmore-Wilhelm Calibrator, see **908.04.C.3.i**.

f. The minimum rotation, from a snug tight condition (10% of the specified proof load), shall be as specified in Table 908.04-2.

Table 908.04-2: Rotation from Snug Tight Condition

Bolt Length	Minimum Rotation from Snug
Up to and including 4 diameters	240 degrees (2/3 turn)
Over 4 diameters, but not exceeding 8 diameters	360 degrees (1 turn)
Over 8 diameters	480 degrees (1-1/3 turn)

(Note: These values differ from those shown in AASHTO M 164 Table 6 and ASTM A325 Table 5.)

g. The tension reached at the above rotation shall be equal to or greater than 1.15 times the required installation tension as specified in Table 908.04-3.

Table 908.04-3: Installation Tension and Turn Test Tension

Bolt Diameter (inches)	Required Installation Tension (kips)	Turn Test Tension (kips)
1/2	12	14
5/8	19	22
3/4	28	32
7/8	39	45
1	51	59
1-1/8	56	64
1-1/4	71	82
1-3/8	85	98
1-1/2	103	118

h. After the required installation tension, as specified in Table 908.04-3 has been exceeded, take and record one reading of tension and torque. The torque value shall conform to the following:

$$Torque < 0.25\,PD$$

Where:

Torque = measured torque (foot-pounds)
P = measured bolt tension (pounds)
D = bolt diameter (feet)

i. Bolts that are too short to test in a Skidmore-Wilhelm Calibrator may be tested in a steel joint. The tension requirement of **908.04.C.3.g** shall not apply. Compute the maximum torque requirement, as specified in **908.04.C.3.h**, using a value of P equal to the turn test tension shown in Table 908.04-3.

D. Documentation

1. Mill Test Report(s) (MTR)

a. Furnish MTR for all mill steel used in the manufacture of the bolts, nuts, and washers.

b. In the MTR, indicate the place where the material was melted and manufactured.

2. Manufacturer Certified Test Report(s) (MCTR)

a. Provide MCTR from the manufacturer of the bolts, nuts, and washers for the items furnished.

b. Each MCTR shall show conformance to all applicable test requirements, the sites where tests were performed, and the date of the tests.

c. In addition to the requirements of **908.04.D.2.a** and **908.04.D.2.b**, the manufacturer performing the rotational-capacity test shall include on the MCTR:

1. The lot number of each of the items tested.
2. The rotational-capacity lot number as required in **908.04.C.3.c**.
3. The results of tests required in **908.04.C.3**.
4. The location where the bolt assembly components were manufactured.

3. Distributor Certified Test Report(s) (DCTR)

a. The DCTR shall include the MCTR data required in **908.04.D.2** above for the various bolt assembly components.

b. The DCTR shall report the rotational-capacity test performed by the distributor or manufacturer.

E. Shipping

Ship bolts, nuts, and washers from each rotational-capacity lot in the same container. If there is only one production lot number for each size of nut and washer, the nuts and washers may be shipped in separate containers. Permanently mark each container with the

rotational-capacity lot number to allow identification at any stage before installation.

908.05 Cast Steel

Provide steel castings conforming to ASTM A27, Grade 65-35.

908.06 Steel Forgings

Provide steel forgings conforming to ASTM A668, Class C1, Annealed. The manufacturer shall furnish the Engineer a record of the annealing charges, showing the forgings in each charge, the melt or melts from which they were secured, the chemical analyses of the respective melts, and the details of the annealing treatment.

908.07 Gray Iron Castings

Provide castings of the type specified and within reasonably close conformity with the dimensions shown on the Plans. The castings shall conform to AASHTO M 105, with the following additions:

1. Unless otherwise specified, all castings shall be Class 30.

2. Cast test bars for tension testing in accordance with AASHTO M 105, Table 2, Test Bar B.

3. Clean all castings of sand and scale by sand blasting or other effective methods so as to present a smooth, clean, and uniform surface.

4. Cast the date of manufacture into all gray iron castings.

5. The lid and lid seat of the rim of manhole castings shall be machined to form a true bearing.

6. All castings shall weigh at least 95% of the theoretical weight shown on the Plans.

908.08 Malleable Castings

Provide castings conforming to ASTM A47, Grade 35018.

908.09 Bronze Bearing Plates, Plain

Provide plates conforming to ASTM B22, Alloy UNS No. C 91100, or ASTM B100, Alloy No. 510.

908.10 Bronze Bearing Plates, Self-Lubricating

Prepare plates from metal conforming to **908.09**. Provide plates with trepanned or drilled recesses (not grooves) to the extent of not less than 25% of their surface areas. The recesses shall be filled by pressure to produce dense non-plastic, lubricating inserts consisting of graphite and metallic substances, held together by a lubricating binder. With each lot of plates, the manufacturer shall supply additional lubricating material in stick form for applying to the surfaces of the steel plates that bear on and move over the lubricating bronze plates.

Furnish the plates from standard production stock by approved manufacturers.

908.11 Corrosion Resistant Steel

Provide corrosion resistant steel conforming to ASTM A588.

Furnish the Engineer a certification from the manufacturer that covers each heat number to be used in the Work and that clearly shows that all requirements of this Specification have been met.

908.12 Elastomeric Bearing Pads

For use as bearings for bridge beams, provide elastomeric bearing pads conforming to Section 18 of the AASHTO LRFD Bridge Construction Specifications.

Unless otherwise specified, provide bearing pads having a shear modulus between 0.080 and 0.175 ksi.

The manufacturer shall provide certified reports on the lot from which each shipment is made, based on tests conducted in its own laboratory or a commercial laboratory designated or approved by the Engineer.

908.13 Copper Sheet for Flashing

Provide sheet copper conforming to ASTM B152 and having a weight per square foot as shown on the Plans.

908.14 Pig Lead

Provide pig lead, conforming to ASTM B29, of common desilverized lead.

908.15 Structural Steel Piles

Provide rolled steel sections of the weight and shape shown on the Plans and that meet the requirements of ASTM A572 or A992, Grade 50 (H-piles) and ASTM A252, Grade 2 or 3 (pipe piles). Do not use steel manufactured by the acid-bessemer process. Ensure that steel piles, when placed in the leads, will not exceed the camber and sweep permitted by the allowable mill tolerance. The Engineer will reject piles that are bent or otherwise damaged.

908.16 Steel Shells

Use steel shells of sufficient strength and rigidity to withstand being driven and to prevent harmful distortion caused by soil pressures or the driving of adjacent piles. Ensure that the shells are sufficiently tight to exclude water during the placing of concrete. The tip and butt diameters shall be as shown on the Plans. Equip shells to be driven without a mandrel with heavy steel driving points. Ensure that the driving points and the connecting welds do not project beyond the perimeter of the pile tips.

908.17 Steel Pipes

Steel pipe to be filled with concrete shall conform to ASTM A252, Grade 2. Closure plates for closed end piles shall conform to ASTM A36.

Provide pipes of the diameter shown on the Plans. The wall thickness shall not be less than that shown on the Plans, but in no case less than 3/16 inch. Provide pipe, including end closures, of sufficient strength to be driven by the specified methods without harmful distortion. Ensure that closure plates and connecting welds do not project beyond the perimeter of the pile tips.

SECTION 909 – FENCE, GUARD RAIL AND BARRIER

909.01 Stock Fence 976
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909.04 Water Gates and Water Crossings 985
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909.08 Guard Rail Hardware 986

909.01 Stock Fence

Unless otherwise specified, the Contractor may choose the type and kind of line post to use, whether wood or steel, and the finish, whether painted or galvanized. Do not change from using one type or kind to the other without the Engineer's written permission. Provide corner posts, end posts, braced line posts, and all fittings and accessories of the same kind and finish as the line post.

A. Fabric

Unless otherwise specified, provide fabric conforming to one of the following:

1. Galvanized steel woven wire meeting ASTM A116 for No. 11 Farm Design No. 1047-6-11, Class III Coating, or

2. Galvanized high tensile strength steel woven wire meeting ASTM A116 for No. 12-1/2 Farm Design, Class III Coating, except that the top and bottom strand shall be 10-1/2 gauge and the yield strength shall be equivalent to No. 11 Farm Design No. 1047-6-11.

B. Steel Posts and Braces

Provide one of the following types of steel line posts, of the lengths shown on the Plans:

1. Studded Tee posts, weighing 1.33 pounds per foot.
2. Lug-U posts, weighing 1.33 pounds per foot.

Furnish each post with a standard anchor plate securely attached to the post.

Provide the following types of end, corner, and braced line posts, of the lengths shown on the Plans:

1. 2-1/2 x 2-1/2 x 1/4 inch angle steel, weighing 4.10 pounds per foot. The braces shall be 2 x 2 x 1/4 inch angle, weighing 3.19 pounds per foot.

2. 2.0-inch (2.375 outside diameter), standard steel black or galvanized pipe, or 2.0 inch (2.375 outside diameter), triple coated steel pipe, with a 0.130-inch minimum wall thickness and coated as specified in **909.02**. Construct the braces of 1.25-inch (1.660 outside diameter) standard steel black or galvanized pipe or 1.25 inch (1.660 outside diameter) triple coated steel pipe with a 0.111-inch minimum wall thickness and coated as specified in **909.02**.

The weights specified for posts and braces are nominal weights, and a plus or minus tolerance of 5% will be allowed.

Furnish the round end, corner, and braced line posts complete with ball caps and other necessary fittings. Furnish galvanized round posts and braces that are galvanized inside and outside in accordance with ASTM F1083.

Galvanize, in accordance with ASTM A123, all steel line posts and steel angle for end, corner, and braced line posts, and braces.

Provide round posts at all corners that vary from 90 degrees.

C. Wood Posts and Braces

Provide wood posts, braces, and anchors of southern pine, oak, Douglas fir, or gum. Cut wood from sound and live trees to the dimensions and shapes shown on the Plans or as otherwise designated. Ensure that the wood contains no unsound knots. Sound knots are allowable, provided the diameter of the knot does not exceed one-third of the diameter of the piece at the point where it occurs. Trim all knots smooth with the face of the timber. The posts shall be free of decayed wood, rot, and ring shake.

The Plans show post and brace sizes in inches. The size refers to the diameter for round pieces and to the edge dimension for square pieces.

The Engineer will allow a tolerance from the dimensions shown on the Plans of ± 1/4 inch for sawed pieces and ± 1/2 inch for round pieces. A tolerance of 2% will be allowed in the length of both round and sawed posts. Saw the ends square, unless otherwise specified.

Peel round posts, braces, and anchors so as to remove all bark and inner skin. Provide timbers having a uniform taper with a slope not greater than 1-1/2 inches in 10 feet. The alignment shall be such that when a line is drawn from the center of the tip to the center of the butt, it shall not fall outside the center of the timber by more than 1% of the length.

Saw sawed posts, braces, and anchors with parallel edges and to not vary more than 1/4 inch from the specified dimensions, except that wane (lack of wood) not exceeding 1/8 of the dimensions of the face and 1/4 of the length of the piece on one corner or the equivalent on two or more corners will be permitted on not more than 10% of the pieces.

Treat posts, braces, and anchors with a preservative treatment, conforming to **911.02.A**. Fabricate or frame the timbers before treatment.

D. Barbed Wire

Provide either galvanized or aluminum-coated barbed wire consisting of two No. 12-1/2 gauge twisted steel line wires with No. 14 gauge 4-point barbs spaced not more than 5 inches apart. The galvanized wire shall meet ASTM A121, chain link fence grade.

The Contractor may use high tensile strength wire, meeting the requirements of ASTM A121, chain link fence grade, for the respective wire size, with barb spacings as designated above.

909.02 Chain Link Fence

Unless otherwise specified, provide one of the following kinds of chain link fence fabric:

1. Zinc coated steel,
2. Aluminum coated steel, or
3. Aluminum alloy.

Do not change from using one kind of fabric to another without the Engineer's written permission.

A. Fabric

Provide fabric of the chain link type, conforming to AASHTO M 181. If galvanized, the fabric shall be of Type I, Class D. Manufacture all chain link fabric of No. 9 gauge wire pickets, forming a uniform 2-inch mesh, and to be of the height shown on the Plans or specified in the Contract.

B. Posts and Braces

1. Description. Manufacture the pipe by cold rolling and electric resistance welding of steel strip conforming to ASTM A1011, ASTM A1008 and A1011, or ASTM A653, Grade D.

Provide corrosion protection to all tubing by in-line application of hot-dip galvanizing, followed by a chromate conversion coating and an electrostatically applied clear acrylic or polyester coating on the outside surface. Provide corrosion protection to the inside surface by hot-dip galvanizing or in-line application of a zinc rich paint after fabrication.

2. Protective Coatings

a. External

i. Apply hot-dipped zinc coating according to ASTM B6 high grade and special high grade. The weight of

the hot-dipped zinc coating shall be a minimum of 0.8 ounces per square foot, as determined in accordance with ASTM A90.

ii. Provide an electrostatically applied clear acrylic or polyester coating thickness of at least 0.1 mils.

b. Internal. Hot-dip galvanize the interior surface with a minimum of 0.9 ounce of zinc, or apply a 0.3-mil thickness of zinc rich paint after welding. Use a coating having at least 80% zinc powder by weight and that is capable of providing galvanic protection.

Provide posts and braces conforming to one of the types specified in Table 909.02-1.

Table 909.02-1: Post and Braces

Application	Material	ASTM Specification	Nominal Diameter (inches)	Outside Diameter (inches)
Line Posts	Galvanized steel pipe	F1083	1.5	1.900
	Aluminum alloy standard (ANSI Schedule 40) pipe	B429, Alloy 6063, Temper T6	1.5	1.900
	Triple coated steel pipe with a 0.120-inch minimum wall thickness	F1043, Group I-C	1.5	1.900

Application	Material	ASTM Specification	Nominal Diameter (inches)	Outside Diameter (inches)
End, Corner, and Pull Posts	Galvanized standard steel pipe	F1083	2.0	2.375
	Aluminum alloy standard (ANSI Schedule 40) pipe	B429, Alloy 6063, Temper T6	2.0	2.375
	Triple coated steel pipe with a 0.130-inch minimum wall thickness	F1043, Group I-C	2.0	2.375
End and Corner Braces	Galvanized standard steel pipe	F1083	1.25	1.660
	Aluminum alloy standard (ANSI Schedule 40) pipe	B429, Alloy 6063, Temper T6 (for corner posts: B241)	1.25	1.660
	Triple coated steel pipe with a 0.111-inch minimum wall thickness	F1043, Group I-C	1.25	1.660

C. Top Rail

Provide top rail conforming to one of the types specified in Table 909.02-2.

Table 909.02-2: Top Rail

Material	Specification	Nominal Diameter (inches)	Outside Diameter (inches)
Galvanized standard steel pipe	ASTM F1083	1.25	1.660
Aluminum alloy standard (ANSI Schedule 40)	ASTM B429, Alloy 6063, Temper T6	1.25	1.660
Triple coated steel pipe with a 0.111-inch minimum wall thickness	ASTM F1043, Group I-C	1.25	1.660

D. Barbed Wire

1. Steel. Provide steel barbed wire meeting **909.01.D**.

2. Aluminum Alloy. Provide aluminum alloy barbed wire consisting of two twisted strands of 0.110-inch line wire with 0.080-inch diameter 4-point barbs spaced not more than 5 inches apart. Use ASTM B211 alloys of 5052-0 for the wire and 5052-H38 for the barbs.

E. Miscellaneous Fittings and Hardware

1. Steel. Provide zinc-coated miscellaneous fittings and hardware of commercial grade steel or better quality, pressed, wrought, or cast as appropriate to the article, and of sufficient strength and other properties to provide a balanced design when used in conjunction with fabric, posts, and wires of the quality specified herein. Galvanize all steel fittings and hardware in accordance with AASHTO M 111.

2. Aluminum Alloy. Provide aluminum alloy miscellaneous fittings and hardware of wrought or cast aluminum conforming to AASHTO M 181, Table I.

F. Wire Ties

Provide No. 9 gauge wire ties of zinc-coated steel, aluminum-coated steel, or aluminum alloy, of sufficient strength and other properties to provide a balanced design when used in conjunction with fabric, posts, and wire of the qualities specified herein.

G. Tension Wire

Provide tension wire meeting AASHTO M 181.

H. Truss Rods and Turnbuckle

Provide truss rods, 5/16-inch in diameter and equipped with a turnbuckle having a take-up of not less than 4 inches. Galvanize rods in accordance with AASHTO M 111.

I. Polyvinyl Chloride Chain Link Fence

Fabricate all posts, fabric and other hardware out of steel meeting the dimensional and material requirements specified herein and coated in accordance with AASHTO M 181, Type IV, Class B.

Fit posts with ornamental tops or extension arms as shown on the Plans. Ornamental tops for tubular posts shall have a base fitting into the post with a flange extending over the top of the posts to protect the post against moisture. Extension arms shall be vertical or extend in or out from the fence line at approximately 45 degrees as shown on the Plans. Provide suitable notches or slots in the extension arms to support and space the barbed wire.

All materials shall be within reasonably close conformity to the sizes, shapes, dimensions, and other factors set out in these Specifications or shown on the Plans, and shall show careful, finished workmanship.

The weights specified for steel posts, braces, and rails are nominal weights, and a plus or minus tolerance of 5% will be allowed.

909.03 Fence Gates

Provide swing-type fence gates of the kinds and sizes shown on the Plans, complete with latches, stops, keepers, hinges, and fabric. Provide latches

that allow for fastening with a padlock. Cover the gates with fabric matching the fence. Provide hinges of adequate strength to support the gate and to not twist or turn under action of the gate. Provide gates, gate posts, and braces of the same kind and finish as the adjoining fence. Furnish all gate posts and rails complete with ball caps and rail ends.

A. Stock Fence Gates

Provide the following for stock fence gates:

1. Posts and braces of standard weight steel pipe conforming to ASTM F1083, or triple coated steel pipe meeting **909.02.B**, furnished with all necessary fittings and of the nominal diameter and length shown on the Plans for the particular gate opening.

2. Gate frames of the type and size specified, constructed in accordance with the details and of the materials shown on the Plans.

3. Fabric of the woven wire type meeting ASTM A116, Class II coating, and of the design shown on the Plans.

4. Barbed wire meeting the requirements of **909.01.D**, and attached to the gate frame as shown on the Plans.

5. Fittings of approved design, made of malleable iron or pressed steel.

Galvanize all gate frames, posts, braces, and fittings in accordance with ASTM F1083 or ASTM A123, as applicable.

B. Chain Link Fence Gates

Provide the following for chain link fence gates:

1. Posts, braces, and framing members of standard weight pipe meeting **909.02.B**. The size and length of the posts and braces and the size and dimensions of framing members shall be as shown on the Plans.

2. Fabric of the chain-link type, meeting **909.02.A**. The height of the fabric shall be that shown on the Plans.

3. Barbed wire meeting the requirements of **909.02.D**.

4. Miscellaneous fittings and accessories meeting the applicable requirements of **909.02.E**, **F**, and **G**, including hinges that will allow the gate to swing back 180 degrees, parallel with the fence line.

909.04 Water Gates and Water Crossings

Provide posts, braces, and accessories of the types, kinds, and dimensions shown on the Plans or directed by the Engineer, and that meet the applicable quality requirements of **909.01** or **909.02**.

Provide timber for water gates of the dimensions shown on the Plans or directed by the Engineer, and that meet the requirements of **911.02**.

909.05 Metal Beam Rail

Provide rail elements of corrugated sheet steel beams conforming to AASHTO M 180, with the following exceptions:

1. Galvanize the beams.

2. Provide the class and type of rail shown on the Plans.

909.06 Timber Rail

Provide timber rail having the dimensions shown on the Plans and meeting the requirements of **911.01**.

Provide treated timber, when specified, conforming to **911.02.A**.

909.07 Guard Rail Posts

Provide railing posts of the section, weight, and length shown on the Plans. The posts may be made of wood, conforming to **911.02.A**, or steel, conforming to ASTM A36 and galvanized in accordance with ASTM A123.

909.08 Guard Rail Hardware

Provide offset brackets of the resilient and non-resilient types of the type specified.

Provide splices and end connections of the type and design specified and of such strength as to develop the full design strength of the rail elements.

Provide end spring assemblies, when specified, that are positive and of a type and design conforming to the intent, design, and strength of the railing structure, as shown on the Plans.

Provide end anchor rods and accessories as specified and of such size and strength as to develop the full design strength of the rail elements.

Unless otherwise specified, galvanize all steel fittings, bolts, washers, and other accessories in accordance with AASHTO M 111 or ASTM A153, whichever may apply. Perform all galvanizing after fabrication. Mechanically applied zinc coating conforming to ASTM B695 and meeting Class 50 coating thickness is an acceptable alternate for the hot-dipped galvanizing specified in AASHTO M 232.

Provide aluminum alloy fittings, bolts, washers, and other accessories as shown on the Plans.

SECTION 910 – PAINT

910.01 General Requirements 987
910.02 Quick Dry Traffic Marking Paint (White and Yellow) 988
910.03 Inorganic Zinc Paint System for Steel Structures 992

910.01 General Requirements

Before having any paint manufactured under these Specifications, contact the Department for a sampling, testing, and inspection procedure. Proportion all paint furnished under these Specifications in accordance with the characteristics specified herein. Perform compounding using ingredients or component materials that have been found to conform with the appropriate detailed Specifications as set forth below by reference or otherwise.

Provide paint that will not compact on settling and will readily return to a smooth, uniform consistency for brushing or spraying when stirred vigorously with suitable paddles or when boxed from container to container.

The Contractor may use 55-gallon drums, equipped with efficient mechanical stirring devices, to deliver shop coat paint to fabricating shops that are equipped to handle them. With the Department's written authorization, the Contractor may also use 55-gallon drums equipped with stirring devices to deliver paints to projects requiring large quantities. In all other cases, deliver lots of 5 gallons or more in 5-gallon circular type metal pails constructed of 26 gauge or heavier metal. Equip each container with a full-top removable and replaceable lid and with a bail of sufficient strength to support the pail when completely filled with the specified paint. Label each container with the name and address of the manufacturer, the kind and color of paint, formula, net content of container, date of manufacture, and lot number.

Have paint that has been stored for longer than 6 months re-inspected and approved prior to use.

910.02 Quick Dry Traffic Marking Paint (White and Yellow)

The following requirements apply to quick dry white and yellow traffic paint, also referred to as pigmented binder, for use in marking traffic lanes or barrier lines on bituminous and concrete highways.

A. General Requirements

Provide pigmented binder formulated to allow for application by spray equipment when heated to 130 °F maximum and applied on bituminous or Portland cement concrete pavements.

B. Drop-on Glass Beads

Use glass beads conforming to AASHTO M 247, Type I.

1. **General.** For pavement markings, use beads that are clear, transparent, colorless glass, smooth and spherically shaped, free of milkiness, pits, or excessive air bubbles, and that conform to the requirements specified herein.

   Glass beads shall not contain more than 200 parts per million of lead or 200 parts per million of arsenic. Certify and ensure that all glass beads meet all Federal requirements. Provide certified test reports demonstrating that all glass beads contain no more than 200 parts per million of arsenic or lead as determined by a certified independent (third party) laboratory, in accordance with Environmental Protection Agency testing methods 3052, 6010B, or 6010C.

   Silica content of the glass beads shall be no less than 60%.

2. **Color and Clarity.** Beads shall be colorless, clear, and free from carbon residues.

3. **Roundness.** Ensure minimum true spheres overall are 80% when tested in accordance with ASTM D1155; for larger beads use visual inspection.

4. **Index of Refraction.** Minimum of 1.50, when tested by the liquid emersion method at 77 °F.

5. Air Inclusions. Maximum of 3% overall.

C. Paint

1. Characteristic Requirements. Provide paint meeting the following requirements:

a. Pigment Content. 58% to 65% by weight. Pigment for white paint shall contain 0.99 pounds per gallon of 94% titanium dioxide. Pigment for yellow paint shall be lead free and contain 0.22 pounds per gallon minimum of 94% titanium dioxide.

b. Total Non-Volatile. 76% by weight, minimum.

c. Vehicle Non-Volatile. 41% by weight, minimum. Vehicle shall be Rohm and Haas E-2706, DOW DT211NA, or an approved equal.

d. Minimum Weight. 13.3 pounds per gallon.

e. Paint Viscosity. 78 to 95 Kreb units when tested at 77±2.0 °F in accordance with ASTM D562.

f. Drying Time

(1) Field: The paint shall dry to a no-tracking condition in 3 minutes when applied at 15 ±1 mil wet film thickness with a bead application rate of 6 pound per gallon of glass spheres per gallon of binder, when the pavement temperature is between 40 and 120 °F and the relative humidity is not exceeding 80%. Apply the pigmented binder with specialized equipment ensuring the binder will have a temperature of 100 to 130 °F at the spray gun. Determine the no-tracking condition by passing over the line as applied above in a simulated passing maneuver with a passenger car travelling 35 miles per hour. Consider a line showing no visual deposition when viewed from a distance of 50 feet as conforming to this drying requirement.

(2) Lab: The pigmented binder without glass spheres shall dry to no-pick-up condition in 10 minutes or less when tested in accordance with ASTM D711.

g. Volatile Organic Compounds (VOCs). Meet the current EPA VOC requirements or 150 grams per liter, whichever is lower.

h. Paint pH. 9.6, minimum.

2. Qualitative Requirements. Provide finished paint meeting the following quality requirements:

a. Condition in Container. The paint received shall show no livering, skinning, mold growth, corrosion of the container, or hard settling of the pigment. Stirring by hand shall readily disperse any settling, with no persistent foaming.

b. Color.

(1) White: After drying, the color shall be flat white, free from tint, furnishing good opacity and visibility under both daylight and artificial light.

(2) Yellow: Color shall closely match chip 33538 of Federal Standard 595B.

c. Flexibility. No cracking or flaking when tested on a 1/2-inch mandrel in accordance with Federal Specification TT-P-1952B.

d. Dry Opacity (Minimum Contrast Ratio). 0.95 when drawn with a 0.005 Bird Applicator.

e. Daylight Directional Reflectance. Not less than 85% for white paint and not less than 50% for yellow (relative to manganese oxide) when measured in accordance with Federal Test Method No. 1416.

f. Bleeding Ratio. 0.97, minimum, when tested in accordance with Federal Specification TT-P-1952B.

g. Scrub Resistance. 300 cycles when tested in accordance with ASTM D 2484.

h. Freeze-Thaw Stability. No change in consistency greater than 10% when tested in accordance with Federal Specification TT-P-1952B.

i. Storage Stability. When stored at 77±4.0 °F in a 3/4-filled can for a period of 30 days, the paint shall be in a homogeneous state with no skinning, curdling, hard settling, or caking that cannot be readily remixed.

D. Inspection, Testing, Packaging, and Marking

After manufacture, send, to the Division of Materials and Tests, a 0.5-pint sample of paint along with certified laboratory analysis for each batch.

For each batch or lot of glass beads shipped for use on Tennessee projects, send, to the Division of Materials and Tests, a 1-quart sample and a manufacturer's certification that the glass beads meet the requirements of AASHTO M 247 for the type beads.

With each shipment of paint and beads, include a detailed analysis for that particular batch and certification that all ingredients meet the requirements set forth in this Specification.

The Department reserves the right to perform in-plant sampling of ingredients and finished product during manufacturing operations and to sample the packaged product when it is received by the Department. The Department may withhold acceptance of the product until it completes its analysis of the samples.

Ship all paint in new containers that can be properly sealed.

Plainly mark or label all containers to show the following information: name and address of manufacturer, kind and color of paint, formula, net content of container, date of manufacture (month and year), and batch number.

910.03 Inorganic Zinc Paint System for Steel Structures

Before the Department will approve the use of any inorganic paint system, submit in triplicate a certified test report from an approved testing laboratory showing specific test results conforming to all requirements of these Specifications.

A. Inorganic Zinc

Provide an inorganic zinc silicate primer with either a vinyl finish coat or an intermediate tie coat followed by a high-build aliphatic urethane finish coat. Provide the finish coat as shown on the Plans and the intermediate tie coat as recommended by the manufacturer of the top coat. Obtain all coatings for use in this system from the same manufacturer to ensure compatibility.

1. **Inorganic Zinc Silicate Primer.** Provide either a two-component or acid catalyzed single component, self-cure ethyl silicate zinc rich paint, which, when mixed and applied in accordance with these Specifications, cures without the use of a separate curing solution and has the properties specified below.

    a. **Pigment.** The zinc portion of the pigment shall be a finely divided zinc powder containing, by weight, a minimum of 96% metallic zinc. All other materials contained in the pigment or pigment component shall be inert.

    b. **Vehicle.** The vehicle component of the two-component type shall have a shelf-life at 77 °F of not less than 12 months.

    c. **Mixed Paint.** The single package paint or the two-compound paint mixed in accordance with the manufacturer's instructions, shall meet the requirements specified in Table 910.03-1.

Table 910.03-1: Requirements for Mixed Inorganic Zinc Silicate Primer

Property	Requirement	
	Single Component	**Two-Component**
Weight per gallon at 77 °F, minimum	17 pounds	17 pounds
Percent total solids, by weight, minimum	67.0%	72.0%
Percent metallic zinc, by weight, of total solids, minimum	81.0%	75.0%

The two-component type shall have a usable pot life of not less than 8 hours at 77 °F. The single component type shall have a storage life of not less than 6 months. During either the pot life or storage life periods, no hard settling shall occur that cannot be easily dispersed.

Formulate the inorganic zinc coating so as to produce a distinct contrast in color with the blast-cleaned metal surfaces and with the vinyl finish coat.

d. Properties of Mixed Paint. Prepare test panels of steel, meeting the requirements of ASTM D609 and having dimensions of 2 x 5 x 1/8 inch, by cleaning all surfaces as specified in **603.05**. Apply a 3-mil coating (dry thickness) to the test plates in accordance with the manufacturer's current printed instructions. Cure the coating according to the manufacturer's recommendations. Perform each of the following tests. If any individual test panel fails any of the following tests, the Engineer will not accept the material.

(1) Fresh Water Resistance. Scribe panels down to base metal with an X of at least 2-inch legs, and immerse in fresh tap water at 75 ±5 °F. The panels shall show no rusting, blistering, or softening when examined after 30 days.

(2) Salt Fog Resistance. Scribe the test panels down to the base metal with an X of at least 2-inch legs, and

then test the panels in accordance with ASTM B117. After 1,000 hours of continuous exposure, the coating shall show no loss of bond, rusting, or blistering beyond 1/16 inch from the center of the scribe mark.

(3) Resistance to Elevated Temperatures and Thermal Shock. Expose panels to a temperature of 500 °F for one hour, then quench immediately in 65 ±5°F water. Panels shall show no blistering or flaking of the coating.

e. Packaging and Labeling. Package inorganic zinc paint in two-component containers or in two separate containers. Package the components in such proportions that the pigment when mixed with the vehicle will yield 5 gallons of mixed paint. Clearly label each container with the name of the manufacturer, brand name of paint, the lot number, and date of manufacture. On the label for the vehicle container, also include complete instructions on the use of the paint. Coat the container if necessary to prevent attack by the paint components.

Submit the manufacturer's current printed instruction for application of inorganic zinc coating to the Materials and Tests Division for review and approval. The manufacturer of the inorganic zinc coating shall furnish a technical representative to assist and advise the applicator in the sandblasting and application of the zinc and vinyl finishes.

2. Intermediate Tie Coat. Use an intermediate tie coat displaying compatibility with and adhesion to the cured inorganic zinc when applied directly over the inorganic zinc paint according to the manufacturer's printed instructions.

3. High Build Aliphatic Polyurethane Finish Coat. Provide a two-component, weather-resistant topcoat, containing no free oils, having excellent resistance to splash and spillage of acids, alkalis, solvents, salts, and water. Ensure it provides adequate hiding when applied in a single coat directly over the intermediate tie coat. The manufacturer will establish a typical density value and tolerance for each component and for the mixed paint.

The minimum weight of the mixed paint shall be no less than 13 pounds per gallon and shall have a solid content of no less than 58% by volume.

Provide mixed paint formulated to allow a single application, without sagging, to yield a 3-mil dry film thickness.

B. Qualified Products List Acceptance

Prior to approval and use of any paint, the manufacturer shall submit in triplicate to the Department a certified test report from an approved testing laboratory showing specific test results conforming to all requirements of these Specifications. The certified test report shall contain the exact ratio, by weight, of the pigment component to the vehicle component of the paint used for the tests, the lot tested, the manufacturer's name, brand name of paint, and date of manufacture. In addition the certified test report shall include data showing that after 250 hours of exposure to 4 hour wet/dry cycles at 122 °F in a QUV cabinet using "B" bulbs, the color will not vary more than 4.0 CIE Lab units from an unexposed control panel.

The Department will place paint meeting the above requirements on its QPL, and will require recertification every 2 years. The manufacturer shall submit certified test results if the manufacturing process or the paint formulation changes. The Department may also require certified test results if random sampling and testing of the material offered for use indicates nonconformance to any of the specified requirements.

C. Certifications

Do not apply any paint, either in the shop or in the field, until the manufacturer of the paint has furnished the Engineer a letter of certification in triplicate stating that the material supplied conforms to the requirements specified above for prequalification and has the same formulation as the prequalified material. The Engineer reserves the right to sample and test the materials supplied.

SECTION 911 – TIMBER AND TIMBER PILES

911.01 Timber 996
911.02 Untreated and Treated Timber 997
911.03 Timber Piles 998

911.01 Timber

A. General

Refer to AASHTO M 168 for grading and terminology. This Section primarily addresses bridge and miscellaneous roadway materials. When using lumber or timbers in buildings (houses or similar type structures), use one of the preservative type treatments noted in AASHTO M 133, applied in accordance with and at the rates specified in the current AWPA procedure for such treatment.

B. Species of Wood

Use Southern Yellow Pine, of at least medium grain, unless otherwise shown on the Plans.

C. Grades of Timber

Lumber ordered in multiple lengths shall be graded after having been cut to length. When shown on the Plans or specified in the Contract, provide lumber for permanent use in structures that is grade marked or hammer stamped by a recognized acceptance agency. Provide timber that conforms to the following:

1. **Yard Lumber.** Provide yard lumber with a C Finish, a choice quality grade for finish purposes, that is reasonably clear and without defects or blemishes that will detract from a finish appearance, especially when painted.

    a. **No. 1.** Sound and tight knotted stock. Size of defects and blemishes limited.

b. No. 2. Allows somewhat (approximately 50%) larger and coarser defects than No. 1. May be considered grain tight lumber.

2. Structural Timber. Provide timber of structural grade conforming to the grading rules of the Southern Pine Inspection Bureau (SPID). Allowable stress shall be in accordance with the current SPIB.

3. Stress Grades for Structural Purposes. Where the Specifications or Plans call for standard stress grades for various structural purposes, provide material of the grades shown on the Plans.

911.02 Untreated and Treated Timber

A. Treated Timber

"Treated timber" refers to timber of the species called for, treated by a pressure method to retain the minimum quantity per cubic foot of the specified preservative. Use preservatives meeting the requirements of AASHTO M 133 for the particular type provided.

For timber that is to be pressure-treated, no heartwood requirement or sapwood limitation shall apply.

The Engineer will not accept treated structural timber for use unless it has been inspected and found satisfactory both before and after treatment.

B. Untreated Timber, Heart Requirements

Ensure that all timber to be used without preservative treatment shows not less than the following amounts of heartwood:

1. Stringers, floorbeams and flooring: 80% of heart of any girth.
2. Caps, sills, and posts: 75% of heart on each of the four sides measured across the side.
3. Bracing, struts, rails, and similar: 80% of heart on both sides measured across the side.

911.03 Timber Piles

A. General

Cut timber piles from live, solid, sound trees, preferably during the winter season. Ensure that timber is free from defects such as injurious ring shakes, large, loose or unsound knots, decay, or other defects that might impair its strength or durability. Sound knots are allowable provided the greatest diameter of the knot does not exceed 4 inches or one-third of the diameter of the pile at the point where it occurs. Saw the butts square.

Fabricate round piles to meet the minimum diameters specified in Table 911.03-1 for the tip and a section 3 feet from the butt, measured under the bark.

Table 911.03-1: Timber Pile Diameters

Length of Pile	Tip Diameter (inches)	Butt End Diameter (inches)
20 feet and under	8	11
Over 20 feet up to 40 feet	8	12
Over 40 feet up to 60 feet	7	12
Over 60 feet	6	13

The diameter of the piles at the butt shall not exceed 18 inches.

Square piles shall have the dimensions shown on the Plans.

Cut piles above the ground swell. Peel all piles so as to remove all the rough or outer bark and at least 80% of the inner bark.

Do not leave any strips of inner bark larger than 3/4 x 8 inches on the pile. Provide a space of at least 1 inch wide between strips. Ensure that at least 80% of any circumference is free from inner bark.

Provide piles that have a uniform taper from butt to tip, are straight grained, and meet the following requirements:

1. A line drawn from the center of the butt to the center of the tip shall not fall outside the center of the pile more than 0.75% of the length at any point.

2. Piles shall be free from reverse bends.

3. 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 4% of the length of the bend or 2-1/2 inches.

4. Trim all knots close to the body of the piles. Piles shall be free from twist exceeding half the circumference in any 20 feet of length.

B. Untreated Timber Piles

Provide untreated timber piles conforming to the general requirements for timber piles specified in **911.03.A**, with the following additions:

1. For piles that will be below water level at all times, the Contractor may provide untreated timber piles of any species of wood that will satisfactorily withstand driving.

2. For use in exposed work, provide untreated timber piles from one of the following species: white oak, post oak, cypress, or southern yellow pine, except loblolly pine. Ensure the piles have a diameter or heartwood of not less than 80% of the required diameter of the pile.

C. Treated Timber Piles

Provide treated timber piles conforming to the general requirements for timber piles specified in **911.03.A**, with the following additions:

1. The Contractor may provide treated timber piles of any species that will satisfactorily withstand driving and that will take the required preservative treatment.

2. Treat the timber piles with a preservative conforming to AASHTO M 133 in accordance with requirements of the current AWPA procedure.

SECTION 912 – BRICK

912.01 Building Brick 1000
912.02 Sewer Brick 1000
912.03 Masonry Mortar 1000
912.04 Concrete Masonry Units 1001

912.01 Building Brick

Provide brick of the kind and grade specified.

A. Clay or Shale Brick

Provide brick conforming to ASTM C62.

B. Concrete Brick

Provide brick conforming to ASTM C55.

912.02 Sewer Brick

Provide brick conforming to ASTM C32.

912.03 Masonry Mortar

Compose mortar of one part Portland cement and two parts sand. The Contractor may add hydrated lime to the Portland cement in an amount not to exceed 10%. Add water to the mixture in quantities that will allow a stiff paste to form.

Either hand-mix or machine-mix the mortar. To prepare hand-mixed mortar, thoroughly mix the sand, cement, and hydrated lime together in a clean, tight, mortar box. Once the mixture is of uniform color, add water. Prepare machine-mixed mortar in an approved mixer, and mix not less than 1-1/2 minutes.

Use mortar within 30 minutes after mixing. Do not retemper mortar.

Use materials conforming to the following:

Cement	**901.01**
Hydrated Lime	ASTM C207
Sand	**903.02**
Water	**921.01**

912.04 Concrete Masonry Units

Provide concrete masonry units conforming to the types, sizes, and dimensions shown on the Plans, and meeting the following requirements, unless otherwise specified:

1. Hollow load-bearing masonry units: ASTM C90, Grade 5, Type II.

2. Hollow non-load-bearing masonry units: ASTM C129, Type II.

Furnish the Department representative samples of the masonry units for testing.

SECTION 913 – CEMENT CONCRETE CURING MATERIALS

913.01 Water 1002
913.02 Earth 1002
913.03 Hay and Straw 1002
913.04 Burlap 1002
913.05 Liquid Membrane-Forming Compounds 1003
913.06 Sheeting Material for Curing Concrete 1003

913.01 Water

For use in curing Portland cement concrete, provide water that is free from all substances that may damage the concrete when applied on the surface as a curing agent.

913.02 Earth

For use in curing Portland cement concrete, provide earth that will retain moisture for a reasonable length of time and that is free of sticks, stones, and other materials that may be detrimental to the surface of the concrete.

913.03 Hay and Straw

For use in curing concrete, provide hay and straw that is reasonably clean and free of sticks or other material that will be detrimental to or mar the concrete.

When using such materials for insulation in cold weather, use materials that are new (not reused) and dry.

913.04 Burlap

Provide burlap conforming to AASHTO M 182, Class 3 or Class 4. If Class 1 or Class 2 burlap is allowed, use at least two layers.

913.05 Liquid Membrane-Forming Compounds

Provide compounds conforming to ASTM C309, and use as follows:

1. Where applied texture finish is specified, use a Type 1-D, Class B, membrane that is compatible with the texture finish.

2. Use either a Type 2 membrane or Type 1-D, Class B, membrane on bridge decks when applied in combination with the water method of curing.

3. Use Type 2 membrane in all other applications.

913.06 Sheeting Material for Curing Concrete

Provide material conforming to the water vapor transmission rates specified in ASTM C171.

SECTION 914 – NON-METALLIC PIPE

914.01 Non-reinforced Concrete Pipe 1004
914.02 Reinforced Concrete Pipe 1004
914.03 Perforated Concrete Pipe 1005
914.04 Drain Tile 1005
914.05 Clay Pipe 1005
914.06 Vitrified Clay Pipe 1005
914.07 Plastic and Polyethylene Corrugated Tubing 1005
914.08 Precast, Concrete Box Sections 1006
914.09 Polyvinyl Chloride (PVC) Pipe 1006
914.10 High Density Polyethylene (HDPE) Pipe 1006
914.11 Steel Reinforced Thermoplastic Ribbed Pipe (SRTRP) 1006
914.12 Polypropylene (PP) Pipe 1006

914.01 Non-reinforced Concrete Pipe

Provide pipe conforming to ASTM C14 for the specified diameters and strength classes.

Manufacture all non-reinforced concrete pipe to meet the Department's procedure for the Manufacture and Acceptance of Precast Drainage Structures, Noise Wall Panels, and Retaining Wall Panels.

914.02 Reinforced Concrete Pipe

Provide pipe conforming to ASTM C76 for the specified diameters and strength classes. Horizontal and vertical elliptical pipe shall conform to ASTM C 507. Arch pipe shall conform to ASTM C 506.

Precast reinforced concrete end sections shall conform to the cited Specifications to the extent to which they apply.

Manufacture all reinforced concrete pipe to meet the Department's procedure for the Manufacture and Acceptance of Precast Drainage Structures, Noise Wall Panels, and Retaining Wall Panels.

914.03 Perforated Concrete Pipe

Provide pipe conforming to AASHTO M 175 or to ASTM C444 for the specified diameters, and, unless otherwise specified, of the standard strength.

914.04 Drain Tile

Provide pipe conforming to AASHTO M 178 for the specified material and diameters, and, unless otherwise specified, of standard quality class. When specified, the pipe spigot shall have integral spacer lugs to provide for an annular opening and self-centering feature.

914.05 Clay Pipe

Provide pipe conforming to ASTM C700 for pipe with full circular cross-section for the specified diameter and strength class. When specified, the bell shall have integral spacer lugs to provide for an annular opening and self-centering feature.

914.06 Vitrified Clay Pipe

Provide pipe conforming to ASTM C700 for the specified diameters and strength classes for circular, unperforated pipe.

914.07 Plastic and Polyethylene Corrugated Tubing

Provide tubing conforming to AASHTO M 252 or ASTM F405 for Heavy Duty Tubing, with the following exception:

> Tubing having an elongation greater than 5% but less than 10% is acceptable provided the minimum pipe stiffness requirements in Table 1 are met when tested in accordance with ASTM F405, Section 8.5, using a 12-inch base plate.

914.08 Precast, Concrete Box Sections

For culverts, storm drains, and sewers, provide precast reinforced concrete box sections conforming to ASTM C1577. Manufacture all precast concrete box sections in accordance with the Department's procedure on the Manufacture and Acceptance of Precast Drainage Structures, Noise Wall Panels, and Retaining Wall Panels.

914.09 Polyvinyl Chloride (PVC) Pipe

Provide PVC pipe conforming to the following:

1. Pressurized Pipe: ASTM D1785.
2. Pipe Culverts: AASHTO M 304.

914.10 High Density Polyethylene (HDPE) Pipe

Provide HDPE pipe conforming to the following:

1. Pipe Culverts: AASHTO M 294, Type S.
2. Slope Drains: AASHTO M 294, Type C or Type S.

914.11 Steel Reinforced Thermoplastic Ribbed Pipe (SRTRP)

Provide SRTRP for pipe culverts conforming to AASHTO MP 20.

914.12 Polypropylene (PP) Pipe

Provide PP pipe for pipe culverts conforming to AASHTO M 330.

SECTION 915 – METALLIC PIPE

915.01 Ductile Iron or Cast Iron Pipe 1007
915.02 Corrugated Metal Pipe Culverts, Pipe Arches, and Underdrains 1007
915.03 Pre-coated, Galvanized Steel Culverts and Underdrains 1008

915.01 Ductile Iron or Cast Iron Pipe

Provide ductile iron pipe conforming to ASTM A716 for the specified diameters and strength classes. Unless otherwise specified, either smooth, corrugated, or ribbed pipe may be furnished. For pipe diameters in excess of 48 inches, conform to ANSI Standard for Cast Iron Pit Cast Pipe, or as otherwise specified in the Contract, for the specified diameter and strength class.

Provide cast iron drain pipe conforming to ASTM A74. Unless otherwise specified, provide ductile iron pressure pipe for water lines or sewer construction conforming to the requirements of ASTM A377 for the diameters and working pressures specified.

915.02 Corrugated Metal Pipe Culverts, Pipe Arches, and Underdrains

A. Zinc-Coated Corrugated Iron or Steel Pipe, Pipe Arches, and Underdrains

Provide zinc-coated (galvanized) corrugated iron or steel pipe, pipe arches, or underdrains, conforming to AASHTO M 36. Use special sections, such as elbows and flared end sections, that conform to AASHTO M 36 and are of the same thickness as the pipe, arch, or underdrain to which they are joined. Furnish shop-formed elliptical pipe and shop-strutted pipe only where shown on the Plans.

B. Aluminum Coated Steel Pipe

Provide aluminum coated steel pipe conforming to AASHTO M 274.

C. Corrugated Aluminum Pipe, Pipe Arches, and Underdrains

When using corrugated aluminum pipe, pipe arches, or underdrains, conform to the applicable requirements of AASHTO M 196. Use special sections, such as elbows and flared end sections, that conform to the applicable requirements of AASHTO M 196 and that are of the same gauge as the conduit to which they are joined.

D. Structural Plate Corrugated Steel and Aluminum Structures

Provide galvanized corrugated structural plate for pipe, pipe arches, and arches conforming to AASHTO M 167.

The Contractor may use mechanically galvanized zinc coating meeting ASTM B695 Class 50 as an alternate for hot-dipped galvanizing (AASHTO M 232) as applicable to hardware for fabrication of structural plate pipe, pipe arches, and arches.

Corrugated aluminum alloy structural plate for pipe, pipe arches, and arches shall conform to the requirements of AASHTO M 219.

E. Bituminous Coating

When material supplied for any of the items specified above are to be bituminous-coated, ensure that the metal to be coated is free of grease, dirt, and other contaminants. Bituminous coating and paving shall conform to the requirements of AASHTO M 190. Apply the coating in accordance with the manufacturer's recommended procedures and as directed by the Department.

915.03 Pre-coated, Galvanized Steel Culverts and Underdrains

Provide pre-coated galvanized steel pipe conforming to AASHTO M 245, Grade 10/10, unless otherwise specified.

SECTION 916 – HIGHWAY SIGNING MATERIALS

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916.02 Aluminum and Composite Material Signs 1009
916.03 Steel 1010
916.04 Stainless Steel 1011
916.05 Fabrication 1011
916.06 Reflective Sheeting 1015
916.07 Legends, Borders, and Accessories 1016
916.08 Flexible Delineator Posts 1020
916.09 Paint 1021

916.01 General Requirements

In constructing highway signs, use all new parts that conform to the requirements of these Specifications, the Plans, and the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, latest edition. To request any departures from the materials and fabrication shown on the Plans or specified in the Specifications, submit details of such departures, and the reasons they are necessary, to the Engineer for approval. Do not make any such departures without the Engineer's prior written approval.

Furnish the Department notarized certified copies of the chemical and physical properties of all materials incorporated in the structures and accessories that are required for this work.

916.02 Aluminum and Composite Material Signs

Provide aluminum and composite materials conforming to the requirements in Table 916.02-1, unless otherwise specified.

Table 916.02-1: Aluminum and Composite Sign Components

Item	ASTM Specification	Alloy and Temper
Flat sign sheets (sign blanks) and plates (permanent and temporary) (1)	B209	6061-T6 or 5052-H38
Extruded shapes (sign panels), bars, rods	B221	6063-T6
Posts and truss chords	B221	6061-T6
Structural shapes	B308	6061-T6
Delineator sheets	B209	6061-T6
Post and truss bracing members	B221	6063-T6
Bolts other than anchor bolts (2)	B211	2024-T4
Nuts, 5/16 inch and larger	B211	6262-T9
Nuts, 1/4 inch and under, tamper-proof type	B211	2024-T4
Washers, Alclad	B209	2024-T4
Flange splicing material	B209	6061-T6
Post caps and chord caps	B26	SG-70A-F
Rivets	B316	6053-T6
Shims	B209	1100-0
Posts clips	B308	6061-T6
Letters, numerals, and symbols	B209	3003-H14

(1) Recycled aluminum flat sheet (sign blanks) meeting ASTM B209, Alloy 6061-T6 or 5052-H38 may be used for temporary signing only. Select composite material sign blanks (temporary signing only) from the Department's QPL. The sign blanks shall be flat and shall contain no visible lateral bow.

(2) Apply chromated sealed anodic coating at least 0.0002 inch thick to all finished bolts.

916.03 Steel

Use steel conforming to the requirements in Table 916.03-1, unless otherwise specified:

Table 916.03-1: Structural Steel and Components

Item	ASTM Specification	Grade
Steel structural shapes [(1)]	A709	50 S
Steel structural plates [(1)]	A709	36
Posts, chord, and bracing members, galvanized	A53	B
Post caps and chord caps [(1)]	A27	--
Bolts, nuts, and washers, galvanized	A307	--

[(1)] Galvanize in accordance with ASTM A123.

916.04 Stainless Steel

Use stainless steel conforming to the following:

1. Stainless steel bolts, washers and screws: ASTM A193, Austenitic steel.

2. Stainless steel nuts: ASTM A194, Grade 8F, except that the nuts shall be lock nuts with semi-finished hex nuts equivalent to American Standard Heavy Series.

916.05 Fabrication

A. General

Fabricate all signs and supports as shown on the Plans. Submit departures from the Plans in the form of shop drawings, as specified in **916.05.B**. Perform work in a uniform, workmanlike manner.

Complete the fabrication of steel components specified to be galvanized, including the forming of holes or perforations, prior to galvanization.

Fabricate all signs and supports in a plant operated by a fabricator who has the necessary experience to manufacture quality signs and supports meeting these Specifications. Before starting fabrication, provide the Department with the name of the proposed fabricators of the signs and

supports, and, if requested by the Department, furnish information as to the fabricator's qualifications and experience.

B. Shop Drawings

For departures from the Plans, submit, for the Engineer's approval, eight copies of shop drawings showing complete detail designs of such departures and all other information necessary to complete the sign assembly.

C. Flat Sheet Signs

Fabricate flat sheet signs of a single piece of sheet aluminum, or composite material (when allowed), without joints and without supporting frame, unless otherwise specified.

D. Multiple Panel Signs

Fabricate multiple panel signs of extruded sections that are 12 inches wide, mounted horizontally, and without vertical joints. Ensure that all panels are flat and straight, and within the commercial tolerances established by the aluminum and composite industry.

E. Overhead Sign Supports

Fabricate overhead sign supports in accordance with the Plans and approved shop drawings.

Perform all welding in the shop in accordance with the Plans and the Contract Special Provisions.

Provide brackets for mounting signs (including future signs) of the type to be supported by the structure. They shall be adjustable to allow mounting of the sign faces at any angle between a truly vertical position and 3 degrees from vertical. Obtain this angle by tilting the top of the sign toward traffic. All brackets shall be of a length equal to the heights of the signs being supported.

Thoroughly clean all steel fabricated components other than stainless steel parts, including clamps and brackets, and galvanize by the hot-dip process, meeting the applicable ASTM Specifications specified in **916.03**.

F. Cutting (Metals)

Saw or mill materials over 1/2-inch thick. Materials 1/2-inch thick or less may be sheared, blanked, sawed, or milled. Ensure that cut edges are true and smooth and free from excessive burrs or ragged breaks.

Fillet re-entrant cuts by drilling prior to cutting.

Do not flame cut aluminum.

G. Bolt Holes (In Metals)

Either drill or blank bolt holes to finished size, provided the diameter of the blanked hole is at least twice the thickness of the metal being blanked.

H. Preparation of Sign Surfaces

Before preparing the surface, complete all fabrication, including cutting, welding, and punching of holes, excluding mounting holes for demountable letters, numerals, symbols, and borders.

Before painting or applying reflective sheeting to the aluminum, treat sign panels in strict accordance with the following procedure:

1. **Preliminary Cleaning.** Completely submerse the surface in a 6% solution of an inhibited alkaline cleaner at 160 to 180 °F for 3 minutes followed by a cold water rinse.

2. **Etching.** Follow preliminary cleaning with a surface etch by immersing the sign for three minutes in a 6 to 8% dilute phosphoric acid solution followed by spraying with a cold water rinse and immersing for 1 minute in circulating hot water at 180 °F.

3. **Handling.** Do not handle any metal, except by device or clean canvas gloves, between cleaning and etching operations and the application of paint or reflective sheeting. Do not allow the metal to come in contact with grease, oils, or other contaminating substances after cleaning and etching and prior to the application of paint or reflective sheeting.

Treat composite material sign panels in accordance with the manufacturer's recommendations

I. Shop Painting and Reflectorization

All legends, borders and background shall be of the color and placed on the sign as shown on the Plans.

1. Application. Apply reflective sheeting to properly treated base panels with mechanical equipment in the manner specified by the sheeting manufacturer. Type II adhesive coated sheeting shall be pre-perforated.

For sign faces consisting of two or more pieces or panels of reflective sheeting, carefully match pieces for color at the time of sign fabrication to provide uniform appearance and brilliance, both day and night. Apply alternate, successive width sections of either sheeting or panels to be reverse and consecutive to ensure that corresponding edges of reflective sheeting lie adjacent on finished sign. Nonconformance may result in non-uniform shading and an undesirable contrast between adjacent widths of applied sheeting that will not be acceptable. Limit splices. When spliced, overlap Type I adhesive coated sheeting not less than 3/16 inch. Type II adhesive coated sheeting may be spliced with an overlap of not less than 3/16 inch or butted; when butted, ensure that the gaps do not exceed 1/32 inch. Only use butt splices on signs screen processed with transparent color. Extend sheeting applied to extruded sections over top edges and down side legs a minimum of 1/16 inch. Ensure that, after aging 48 hours at 75 °F, adhesion of reflective sheeting to sign surface is strong enough to resist stripping from the panel when tested with a stiff putty knife, and will meet other applicable requirements as specified for Reflective Sheeting in **916.06**.

2. Silk Screening. Apply all legends and borders on signs, except demountable or cut-out legends and borders, by silk screening after the sheeting is attached to the panels, unless otherwise approved by the Engineer. Perform all screening in a workmanlike manner and as recommended by the manufacturer of the reflective sheeting.

The Contractor may apply black legends and borders to signs having silver reflectorized backgrounds by equally effective methods when approved by the Engineer. Use proper size screen

mesh in reverse screening to ensure that the finished colors match the prescribed Standard Interstate Colors (AASHTO Manual). Noticeable deviation from the shades is cause for rejection of the sign.

After silk screening, or reverse silk screening, bake the sign in an approved oven for a period of one hour, at a temperature of 200 °F.

J. Packaging

Package signs in a manner that will prevent damage to any part of the sign, including demountable legends or borders, during shipment and storage. Before packaging, ensure that signs are free of moisture and paints are thoroughly dry. Do not apply adhesive tapes to any sign surfaces. Keep all packaged signs entirely dry.

Securely attach braces to all assembled or partially assembled signs, other than flat sheet signs, to prevent buckling or warping from the time of assembling to attaching on permanent supports.

916.06 Reflective Sheeting

Provide reflective sheeting conforming to AASHTO M 268 and the supplementary requirements for fungus resistance of AASHTO M 268. The sheeting material shall have a precoated adhesive backing or a heat and pressure activated adhesive backing protected by a removable liner.

For all signs with a SILVER-WHITE and ORANGE background when used on temporary barricades and channelizing drums, provide reflective sheeting of Type B or better as specified by AASHTO M 268.

For all signs with a SILVER-WHITE, YELLOW, RED, GREEN, BROWN, or BLUE background, provide reflective sheeting of Encapsulated Lens or Micro-prismatic Lens material meeting or exceeding the minimum requirements for Type B or better as specified by AASHTO M 268.

FLOURESCENT ORANGE background material shall meet or exceed the requirements for Type B, as specified by AASHTO M 268.

916.07 Legends, Borders, and Accessories

Provide letters, numerals, symbols, borders, and route markers conforming to the MUTCD.

A. Type "A" Class I (Demountable)

Provide silver-white letters, numerals, symbols, borders, and route markers of a pre-coated pressure sensitive or a tack-free heat-activated adhesive reflective sheeting permanently adhered to the sign panel. The reflective sheeting shall meet the requirements of **916.06** (Type B or better as specified by AASHTO M 268).

Mechanically apply the reflective sheeting to the properly prepared sign panel with the equipment and in a manner prescribed by the sheeting manufacturer. Letters, numerals, symbols, borders, and route markers shall be 0.032 inch thick aluminum sheet of 3003 H14 Alloy or approved composite material. Properly degrease and etch aluminum, or treat with a light, tight, amorphous chromate type coating.

Supply each letter, numeral, symbol, and route marker with mounting holes, and secure to the sign surface with corrosion-resistant screws, bolts, or rivets.

B. Type "A" Class 2 Cut-Out (Direct Applied Reflective Sheeting Copy)

Provide silver-white cut-out letters, numerals, symbols, borders, and route markers of a pre-coated pressure sensitive or a tack-free heat-activated adhesive reflective sheeting. The reflective sheeting shall meet the requirements of **916.06** (Type B or better as specified by AASHTO M 268).

C. Type "B"

1. **General.** Provide demountable sign letters, digits, arrows, borders, and alphabet accessories, conforming to the Standard Alphabet for Highway Signs of the FHWA, and reflectorize them using acrylic plastic prismatic reflectors supported by embossed aluminum frames.

   Use reflectors of acrylic plastic meeting the requirements of Federal Specification L-P-380, Type 1, Class 3. Identify the

material manufacturer and the particular molding compound so that the Department may readily check the suitability of the raw material used in the reflectors.

The reflectors shall consist of a clear and transparent plastic face (referred to as the lens) and an opaque plastic back of identical material fused to the lens under heat and pressure around the entire perimeter to form a homogeneous unit permanently sealed against dust, water, and water vapor. The reflector shall be colorless.

The lens shall consist of a smooth front surface free from projections or indentations other than for identification, and a rear surface bearing a prismatic configuration that will effect total internal reflection of light. The manufacturer's trade mark shall be molded legibly into the face of the lens.

2. Optical Requirements

a. Specific Brightness. The specific brightness of each reflector intended for use in cut-out letters, symbols, and accessories shall be equal to or exceed the minimum values specified in Table 916.07-1, with measurements made with reflectors spinning. Failure to meet the specific brightness minimum will result in failure of the reflector being tested. Failure of more than two reflectors out of fifty tested will result in failure of the lot.

Table 916.07-1: Specific Brightness for Reflectors

Observation Angle Degrees	Entrance Angle Degrees	Specific Brightness $Cd/m^2/lux$
1/10	0	14.0
1/10	20	5.6
1/6	0	10.0
1/6	20	4.0
1/3	0	7.0
1/3	20	2.8

For amber reflectors, the specific brightness minimum shall be 60% of the value shown for crystal.

b. Optical Testing Procedure. Locate the reflector to be tested at a distance of 100 feet from a single uniformly bright light source having an effective diameter of 2 inches. Operate the light source at approximately normal efficiency. Measure the return light from the reflector using a photoelectric photometer having a minimum sensitivity of 1×10^{-7} footcandles per scale division.

The photometer shall have a receiver aperture of 1/2-inch diameter, shielded to eliminate stray light. The distance from light source center to aperture center shall be 2.1 inches for 1/10 degree observation angle, 3.5 inches for 1/6 degree observation angle, and 6.9 inches for 1/3 degree observation angle. During testing, spin the reflectors so as to average the orientation effect.

If using a test distance other than 100 feet, modify the source and aperture dimensions and the distance between source and aperture in the same proportion as the test distance.

3. Durability

a. Seal Test. Perform the following test to determine if a reflector is adequately sealed against dust and water.

1. Submerge fifty samples in a water bath at room temperature.

2. Subject the submerged samples to a vacuum of 5-inch gauge for 5 minutes.

3. Restore atmospheric pressure and leave samples for water intake.

4. Intake of water in any form constitutes failure. Failure of more than 2% of the number tested is cause for rejection of the entire lot.

b. Heat Resistance Test. Perform the test as follows:

1. Test three reflectors for 4 hours in a circulating air oven at 175 °F.

2. Place the test specimens in a horizontal position on a grid or perforated shelf allowing free air circulation.

3. At the conclusion of the test, remove the samples from the oven and allow to cool in air to room temperature.

4. Ensure that the samples after exposure to heat show no significant change in shape and general appearance when compared with unexposed control standards.

c. Corrosion Test. Ensure that the assembled cut-out letter, symbol, or accessory can withstand the combined corrosion test performed in accordance with ASTM B117.

4. Fabrication. Fabricate all items except border strips from 0.040-inch sheet aluminum or approved composite material. Fabricate border strips from 0.032-inch aluminum, or composite material.

Provide mounting holes within the frames, in accordance with the manufacturer's directions, to allow the use of screws, rivets, or other acceptable fasteners.

Size and space reflector holes to provide for maximum night legibility and visibility of the finished cut-out figure.

5. **Finishing.** After the metal fabrication has been completed, perform the following finishing process:

   a. **Preparation.** Prepare aluminum frame surfaces as specified in **916.05.H**, and treat with Alodine 1200, Iridite 14-2, Bonderite 721, or equal product, in strict accordance with the recommendations of the chemical manufacturer.

   b. **Enameling.** After treating, finish the frames in the color specified with baking enamel, in strict accordance with the recommendations of the enamel manufacturer.

916.08 Flexible Delineator Posts

Provide delineator posts of the height shown on the Plans and of a width that presents a minimum 3-inch wide profile in the direction of approaching traffic. The top 14 inches of the front of the delineator post shall have a smooth surface capable of readily bonding the pressure sensitive reflective sheeting.

Provide delineator posts that are white in color unless otherwise shown on the Plans. Reflectorize the posts with reflective sheeting that conforms to AASHTO M 268, Type B or better retroreflection performance level.

The reflective sheeting strip on the delineators shall be 9 inches in length and of sufficient width to provide a 3-inch wide profile facing approaching traffic. Locate the top of the reflective sheeting 1/2 inch from the top of the delineator post.

For Flexible Type II Object Markers, use reflective sheeting consisting of three yellow squares spaced 4-1/2 inches center to center, each square being 3 inches long with sufficient width to present a 3-inch wide profile when mounted on a post. Locate the top square 1/2 inch from the top of the object marker post.

Select material from the Department's QPL. The manufacturer shall certify that the materials to be supplied are formulated the same as when tested by the National Transportation Products Evaluation Program and will conform to the requirements of this Specification. The Department reserves the right to periodically sample and test delineator posts.

916.09 Paint

Provide paint that conforms to the requirements specified below, or approved equal, and that is produced by a properly equipped manufacturer who has had prior experience in manufacturing paints of the general character specified and who can cite applications, other than sample panels, of paints of this general character of which satisfactory service has been provided for a period of not less than 5 years.

1. For nonreflectorized message application, provide black paint of a high quality opaque process paste made with synthetic resin as manufactured or recommended by the manufacturer of the reflective sheeting.

2. For application on the silver reflective sheeting for signs and reflectorized backgrounds, provide transparent blue, red, and green paint and thinner as recommended by the manufacturer of the reflective sheeting. Ensure that the colors, when thoroughly dry, match the Standard Interstate Colors (AASHTO Manual) when compared in natural daylight.

SECTION 917 – ROADWAY AND STRUCTURE LIGHTING MATERIALS

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917.01 General Requirements

Prior to making any purchases, submit for approval a complete list of all proposed materials. Include on the list the manufacturer's name, catalog number, and such other definitive or descriptive data as is necessary to adequately define the item. When requested by the Engineer, furnish samples of the material and notarized certificates by the manufacturer that the material meets the requirements of these Specifications and all industry standards referred to herein.

Obtain all guarantees on mechanical and electrical equipment furnished by the manufacturer, and submit them to the Engineer. The Engineer will then transmit these guarantees to the agency responsible for future maintenance of the equipment.

Provide material and equipment that is designed, manufactured, and tested in accordance with the requirements of at least one of the following societies: ASTM, IPCEA, NEMA, IEEE, ANSI, and AASHTO. Provide material that is UL approved and bears the UL label.

Only furnish new materials and equipment under these Specifications.

917.02 Roadway Lighting Standards

Meet the following requirements for prestressed concrete, aluminum, and steel lighting standards.

Furnish standards of the design and dimensions shown on the Plans, and that conform with AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals. Include calculations for the design of each type of pole and bracket arm length with the shop drawings when submitted for approval.

A. Prestressed Concrete

1. **Scope.** These Specifications apply only to the manufacture of concrete lighting standards used to support lighting units.

2. **Method of Manufacture.** Manufacture all standards by an approved method that will ensure dense and uniform concrete. Place the concrete in one continuous operation. Use a manufacturing method that will produce a smooth cable raceway of 2 inches up to the hand hole, and a 1-inch raceway above the hand hole.

3. **Curing.** Following the casting operation, cure the concrete with low temperature saturated steam. Following the steam curing and while reducing the curing temperature, do not subject the standards to severe temperature changes.

4. **Anchor Base.** Furnish standards with the type of base shown on the Plans. Cast the base as an integral part of the standard.

5. **Foundations.** Where shown on the Plans, furnish the standards with a precast butt foundation that is cast as an integral part of the standard. Provide a conduit entrance slot of not less than 2 x 9 inches in the precast butt base at the location shown on the Plans.

6. **Anchor Bolts.** Use anchor bolts of high-strength steel meeting the requirements of ASTM F1554, Grade 55, and having a minimum yield strength of 55,000 pounds per square inch and a minimum ultimate strength of 90,000 pounds per square inch. Fit each anchor bolt with a hex nut and lock-washer.

7. **Aluminum Bracket Arm.** Fabricate aluminum bracket arms, if specified, from aluminum alloy pipe or tapered tubes. Use pipe conforming to the requirements for nominal 2-inch diameter or larger Schedule 40 pipe of aluminum alloy 6063-T6, ASTM B241. Use tapered tubes conforming to the requirements for aluminum alloy 6063-T6, ASTM B221. Use cast aluminum clamps of Aluminum Alloy No. B-443.

8. **Steel Bracket Arms.** Fabricate steel bracket arms, if specified, from nominal 2-inch diameter or larger Schedule 40 pipe conforming to ASTM A53. Galvanize the steel bracket arm after fabrication in accordance with ASTM A123. Take precautions to obtain high quality galvanized coatings in accordance with ASTM A385.

   The design and dimensions of the bracket arm assembly shall be as shown on the Plans. Ensure that the installed bracket will provide a weather-resistant connection with smooth wiring raceway. Use stainless steel bolts and nuts. Hot-dip galvanize all other steel parts and associated hardware in accordance with ASTM A123 or ASTM A153.

B. Aluminum

1. **Scope.** These Specifications apply only to the manufacture of aluminum lighting standards used to support lighting units.

2. **General.** Provide poles consisting of an aluminum shaft having a base attached to the lower end and complete with anchor bolts where required. Use materials conforming to the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals. Perform welding in accordance with AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

3. **Shaft.** Provide a shaft of either spun seamless tubing or formed sheet aluminum. The shaft may have one continuous longitudinal

weld. Provide the pole shaft with a uniform taper of approximately 0.14 inch per foot, or taper in increments as approved by the Engineer.

Furnish shafts in either one or two pieces in accordance with the manufacturer's current practices; however, if the required shaft length exceeds standard shipping limits, furnish the shaft in two pieces.

Assemble the two-piece shafts by telescoping the upper section over the lower section with a firm tapered fit. The telescoping length of the shaft shall be not less than 14 inches. Assemble the shaft in the presence of the Engineer or a qualified representative authorized by the Engineer. Ensure that the sections are correctly plumbed and force fitted. Do not weld the joint.

Provide an opening near the top of the shaft to provide a cable entrance from the shaft into the bracket arm. Design the opening to provide a smooth cable guide for wiring. Equip the top of the shaft with a removable pole top of aluminum alloy held securely in place with set screws. The shaft (excluding transformer base standards) shall have a reinforced handhole, of the size shown on the Plans, with a bolt-on cover. Provide a grounding nut or lug for accommodating a 1/2-inch UNC threaded bolt or stud in the shaft or base.

4. **Anchor Base.** The shaft shall have an anchor base that is strong enough to develop the full strength of the shaft it supports. Provide the base with four holes to receive the anchor bolts and a suitable means for attaching bolt covers. Provide four removable bolt covers with each base.

5. **Breakaway Device.** Provide a breakaway device conforming to the breakaway characteristics as established by Section 12 of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

   To determine if an item meets the breakaway requirements of the AASHTO Standard Specifications, follow testing and reporting procedures comparable to those given in NCHRP Report 153. Acceptance may be based on a single test if the test change in momentum and the analytically inferred changes in momentum over the speed range are less than 750 pound-seconds. If the first

dynamic test change in momentum is between 750 and 1,100 pound-seconds, perform a second dynamic test unless assurance that the test results are representative of what would result from further dynamic tests can be demonstrated analytically and statically. The results of the second test must also meet the specification requirements. Furnish documentation of the breakaway characteristics to the Engineer prior to fabrication.

6. **Bracket Arm Aluminum.** Provide bracket arms for aluminum standards that meet the same requirements as specified in **917.02.A.7** for aluminum bracket arms for concrete standards.

7. **Anchor Bolts.** Provide anchor bolts of high-strength steel, each fitted with a hex nut and lock-washer. Each anchor bolt shall be capable of anchoring the bottom end in the concrete foundation and shall be threaded at the top end. The exposed portion of the threaded end of the anchor bolt, all nuts, washers, couplings, studs, and other fasterners shall be zinc coated, unless otherwise specified, in accordance with ASTM A153. Ensure that the anchor bolts are capable of resisting, at yield strength stress, the bending moment of the shaft at its yield strength stress.

8. **Finish.** All hardware not otherwise specified shall be aluminum or stainless steel. Furnish all materials in natural aluminum color. Furnish pole shafts with either a polished or brush finished surface. Tire-wrap shaft and bracket arm assemblies with a heavy water-resistant paper to provide protection during shipment and installation.

C. Steel

1. **Scope.** These Specifications apply only to the manufacture of steel lighting standards used to support lighting units.

2. **General.** Provide poles consisting of a steel shaft having a base welded to the lower end and complete with anchor bolts. All castings shall be clean, smooth, with details well defined and true to pattern. Provide gray iron castings conforming to ASTM A126, Class A, or ASTM A48, Class 20. Provide steel castings conforming to ASTM A27, Grade 65-35.

3. **Anchor Base.** Secure a one-piece cast steel base, having adequate strength, shape, size, and chamfer, to the lower end of the shaft by

two continuous electric arc welds. The base shall telescope the shaft. Make one weld on the inside of the base at the end of the shaft; make the other weld on the outside at the top of the base so that the welded connection will develop the full strength of the adjacent shaft section to resist bending action.

Provide four removable anchor bolt covers with each base. Attach each cover to the body of the base using suitable means. Provide a transformer base, if specified, of the design, dimensions, and material shown on the Plans.

4. Breakaway Device. Provide breakaway devices conforming to the same requirements as specified in **917.02.B.5** for aluminum poles.

5. Shaft. The steel shaft may have only one longitudinal electrically welded joint and shall not have any intermediate horizontal joints or welds. Use only one length of steel sheet, and form it into a continuous shaft.

Fabricate the shaft from not less than No. 11 gauge steel conforming to the requirements of ASTM A242, ASTM A595, ASTM A606, or A1008 and A1011.

After forming and welding, longitudinally cold-roll the shaft under sufficient pressure to flatten the weld and increase the physical characteristics of the shaft so that the metal will have a minimum guaranteed yield strength of 48,000 pounds per square inch. The shaft (excluding transformer base standards) shall have a reinforced handhole, of the size shown on the Plans, with a bolt-on cover. Provide a ground nut or lug for accommodating a 1/2-inch UNC threaded bolt or stud in the shaft or base. Equip the top of the shaft with a pole cap held securely in place by set screws.

6. Bracket Arm Steel. Provide bracket arms for steel standards that meet the same requirements as specified in **917.02.A.8** for steel bracket arms for concrete standards.

7. Anchor Bolts. Provide anchor bolts for steel standards that meet the same requirements as specified in **917.02.B.7** for anchor bolts for aluminum standards.

8. Finish. Either paint or galvanize steel lighting standards as shown on the Plans and in accordance with the following:

a. When painting is permitted or specified, thoroughly clean all materials not to be galvanized and shop paint with one coat of zinc chromate primer meeting the requirements of **910.03** before the parts are handled or packaged for shipment.

b. Galvanize steel standards and bracket arms, and fittings, except hardware and anchor bolts, in accordance with ASTM A123. Galvanize hardware and anchor bolts in accordance with ASTM A153.

D. High Mast

1. Scope. These Specifications apply only to the manufacture of steel lighting standards over 55 feet in length used to support head frame, ring assembly, suspension, and power cables and luminaires.

2. General. Provide poles consisting of a steel shaft, handhole, anchor base, head frame, suspension cables, power cables, anchor bolts and foundation, and all equipment to complete the installation. Provide standards conforming to the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

3. Shaft. Provide shafts tapered from top to bottom, either cylindrical or multi-sided in cross-section, and of either single-piece or slip-fit multi-section construction. Slip-fit design shall consist of tapered sections that telescope each other, and are fabricated so that the minimum length of the overlap joint is 1-1/2 times the maximum inside diameter of the overlapping section. Number each section and show minimum and maximum overlap.

(a) Provide weathering steel shafts conforming to ASTM A595 Grade C; and miscellaneous plates, bars, and structural shapes conforming to ASTM A709 Grade 50 S. Fabricate and weld these poles in accordance with AWS 01.1.

(b) Provide galvanized steel shafts of high strength steel, cold formed fabricated with one longitudinal weld and having a minimum yield strength of 50,000 pounds per square inch and a maximum specified yield strength of 65,000 pounds per square inch after fabrication. Base the design on the yield strength of the material used but not to exceed 60,000 pounds per square inch. Hot-dip galvanize the shaft in accordance with ASTM A123.

917.03 Lighting Assembly Strength Test

Ensure that the complete assembly of all standards, except high mast, when placed upright on a suitable foundation meets the following strength requirements:

1. A vertical load of 100 pounds applied at the point of luminaire attachment shall not produce a deflection in excess of 5% of the horizontal length of the bracket.

2. A vertical load of 250 pounds applied at the same point as in (1) above shall not produce collapse, rupture, or permanent deformation of any portion of the assembly.

3. A horizontal load of 60 pounds applied at the point of luminaire attachment and normal to plans of bracket assembly shall not produce a horizontal deflection in excess of 5% of the horizontal length of the bracket.

4. A horizontal load of 500 pounds applied at the top of the shaft, in any direction, shall not produce a deflection in excess of 8% of the length of the shaft nor shall this load cause failure of any component part of the assembly.

Furnish a signed warranty from the manufacturer stating that the materials used in standard and bracket fabrication fully meet the requirements of these Specifications and will satisfactorily withstand the specified horizontal and vertical loads in the above tests.

917.04 Wiring

Use conductor cable of the size and type shown on the Plans and in strict compliance with the National Electrical Code, the National Electrical Safety Code, and local codes.

Unless otherwise shown on the Plans, for all conductor cable placed in conduits and light standards, use single-conductor AWG copper with UL rated 600 volt type insulation suitable for wet or dry installation with the conductor temperature not exceeding 167 °F.

Provide direct-burial cable and cable in-duct as shown on the Plans.

917.05 Metallic Conduit

Provide rigid steel conduit conforming to Federal Specifications WW-C-581 or ANSI C 80.1. Galvanize the conduit inside and outside by one of the following processes: hot-dip galvanizing, metallized galvanizing, or electro-galvanizing.

Provide flexible metal conduit conforming to Federal Specification WW-C-566.

Provide aluminum conduit conforming to Federal Specification WW-C-540.

Where welded steel pipe for ordinary use is shown on the Plans, provide pipe that is hot-dip galvanized inside and out and that meets ASTM A53 for Welded Steel Pipe for ordinary uses.

917.06 Metallic Conduit Fittings

Provide galvanized steel conduit fittings conforming to Federal Specifications WW-C-581 or ANSI C-80.4.

917.07 Non-metallic Rigid Conduit

Provide non-metallic rigid conduits and fittings of polyvinyl chloride (PVC), of Schedule 40 or 80 as specified, and conforming to ASTM D1785 for conduit and ASTM D2466 for fittings; or polyethylene conduit meeting the requirements of ASTM D1248 or as specified in the Contract.

917.08 Luminaires

Provide luminaires, complete with power regulated ballast, lamps, insulating transformer (where required), and associated hardware and wiring. Luminaires shall use and include a high intensity discharge lamp of the type shown on the Plans.

Ensure that the luminaires are capable of providing the specified illumination level and uniformity of illumination when installed as shown on the Plans. Photometric and electrical requirements shall equal or exceed the requirements shown on the Plans.

917.09 Fittings, Pull Boxes, and Bends

Provide fittings, pull-boxes, bends, and miscellaneous hardware in accordance with the Plans and the National Electrical Code, and that are compatible with the adjacent conduit and materials.

917.10 Relays, Switches, Control Cabinets, Etc.

Provide relays, switches, control cabinets, and miscellaneous electrical equipment in accordance with the applicable codes and as shown on the Plans.

917.11 Service Poles and Wood Standards

Provide wood service poles and standards of the class and length shown on the Plans. Unless otherwise specified, provide poles and standards of treated southern pine, classified according to the latest American Standard Dimensions of Southern Pine Poles, and that meet the requirements of ANSI 05.1. Treat the poles with pentachlorophenol or other approved treatment at the rate recommended by the local power authority, unless otherwise specified. The treatment shall conform to **911.03.C**.

Provide metal service poles of the kind, design, type, and dimensions shown on the Plans.

917.12 Guying Components

Provide guying components for wood poles consisting of zinc-coated wire strand, zinc-coated anchor rod, four-way expanding anchor, and necessary accessories. Use wire strand conforming to the requirements of ASTM A475 for the particular grade, size, and type specified. Hot-dip galvanize the anchor rod, anchor, and accessories.

All guying components shall be in accordance with the details shown on the Plans.

917.13 Grounding Materials

Provide grounding materials as shown on the Plans. Use clamps that are designed for use with the designated rods.

917.14 Splicing Materials

Use splicing materials as shown on the Plans and of a design and material consistent with the location and type of splice indicated.

917.15 Drag Wire

For drag wire to be installed in the conduit, use nine-gauge galvanized iron wire, unless otherwise specified.

917.16 Photoelectric Relay

For the photoelectric relay for operating the multiple relays in the control center, provide a unit type assembly with a locking type plug that will allow the unit to be easily removed for maintenance purposes.

The photoelectric relay shall operate from 105 to 285 volts, shall have a minimum control range of 0.5 to 5.0 footcandles, and shall have a sensitivity adjustment for both on and off for the total range. The relay contacts shall be able to handle a minimum of 1,000 watts at 250 volts.

SECTION 918 – LANDSCAPING MATERIALS

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918.02 Commercial Fertilizer 1036
918.03 Ammonium Nitrate 1036
918.04 Agricultural Limestone 1036
918.05 Mulch Material 1036
918.06 Inoculants for Legumes 1037

918.01 Grass Seed

A. General

Provide seed meeting the requirements of the Tennessee Department of Agriculture. The Engineer will accept no "Below Standard" seed.

Pack grass seed in new bags or bags that are sound and not mended.

The vendor shall notify the Department before making shipments to allow the Department to arrange for inspection and testing of stock.

The vendor shall furnish the Department a certified laboratory report from an accredited commercial seed laboratory or from a State seed laboratory showing the analysis of the seed to be furnished. The report from an accredited commercial seed laboratory shall be signed by a Registered Member of the Society of Commercial Seed Technologists. The Department may take samples of the seed to check against the certified laboratory report. Sampling and testing will be in accordance with the requirements of the Tennessee Department of Agriculture.

Use commercial grade 10-10-10 fertilizer or equivalent.

B. Seed Groups

When a seed group is used, provide mixtures meeting the requirements specified in Tables 918.01-1 through 918.01-5, unless otherwise specified.

Table 918.01-1: Group A (February 1-July 1)

Kind of Seed	Quantity, Percent by Weight
Kentucky 31 Fescue	80
Korean Lespedeza	15
English Rye	5

Table 918.01-2: Group B (June 1-August 15)

Kind of Seed	Quantity, Percent by Weight
Kentucky 31 Fescue	55
English Rye	20
Korean Lespedeza	15
German Millet	10

Table 918.01-3: Group B1 (April 15 - August 15)

Kind of Seed	Quantity, Percent by Weight
Bermudagrass (hulled)	70
Annual Lespedeza	30

Table 918.01-4: Group C (August 1-December 1)

Kind of Seed	Quantity, Percent by Weight
Kentucky 31 Fescue	70
English Rye	20
White Clover	10

Table 918.01-5: Group C1 (February 1-December 1)

Kind of Seed	Quantity, Percent by Weight
Crown Vetch	25
Kentucky 31 Fescue	70
English Rye	5

Uniformly mix seed when forming Groups. Do not mix Group seed until each type seed that is used to form the Group has been tested and inspected separately and approved for purity and germination by the Department. Seed mixed before tests and inspection are made will not be accepted.

C. Over-Seeding

Groups A, B, and C, when sown on slopes 3:1 and steeper, shall be over seeded with Sericea Lespedeza at the rate of 15 pounds per acre. When over-seeding is performed between February 1 and July 1, use Scarified Sericea Lespedeza with an additional 2 pounds per acre of Weeping Lovegrass. Between July 1 and December, use unhulled Sericea Lespedeza. Only use Group C1 when shown on the Plans.

D. Temporary Seeding

For temporary seeding, use seed groups and approved varieties as specified in Table 918.01-6.

Table 918.01-6: Temporary Seeding

Seed Group (Season)	Kind of Seed	Percent by Weight
Group D (January 1 – May 1)	Italian Rye	33-1/3%
	Korean Lespedeza	33-1/3%
	Summer Oats	33-1/3%
Group E (May 1 – July 15)	Sudan-Sorghum Crosses [(1)]	100%
	or	
	Starr Millet [(2)]	100%
Group F July 15 – January 1	Balboa Rye	66-2/3%
	Italian Rye	33-1/3%

[(1)] Dekalb Sudan SX11, Lindsey 77F, TN Farmer's Co-op GHS-1 or GHS-2A.

[(2)] Starr Millet, GaHi-1

918.02 Commercial Fertilizer

Provide a standard commercial fertilizer containing the specified percentages by weight of nitrogen, phosphoric acid, and potash.

Furnish the fertilizer in standard containers, with the name, weight, and guaranteed analysis of the contents clearly marked. Ensure that the containers will adequately protect the fertilizer during handling and transporting.

All commercial fertilizer shall comply with local, State, and Federal fertilizer laws.

918.03 Ammonium Nitrate

For ammonium nitrate, provide a standard commercial product, conforming to the requirements specified in **918.02** for other commercial fertilizers and having a minimum of 33-1/2% nitrogen.

918.04 Agricultural Limestone

Provide agricultural limestone, containing at least 85% of calcium carbonate and magnesium carbonate combined, and that is crushed so that at least 85% will pass the No. 10 sieve and 50% will pass a No. 40 sieve.

918.05 Mulch Material

Ensure that all hay and straw mulch materials are air dried and reasonably free of noxious weeds and weed seeds or other materials detrimental to plant growth on the highway or on adjacent agricultural lands.

Provide hay derived from stalks of approved grasses, sedges, or legumes seasoned before baling or loading.

Provide straw derived from stalks of rye, oats, wheat, or other approved grain crops.

Both hay and straw shall be suitable for spreading with standard mulch blower equipment.

Provide an approved tackifier, selected from the QPL, to hold mulch in place.

918.06 Inoculants for Legumes

For treating legume seed, provide inoculants composed of standard cultures of nitrogen-fixing bacteria that are adapted to the particular kind of seed to be treated. Provide the inoculant in convenient containers, of a size sufficient to treat the amount of seed to be planted and that contain labels identifying the specified legume seed to be inoculated and the date period to be used.

SECTION 919 – PAVEMENT MARKING MATERIAL AND MARKERS

919.01 Thermoplastic Pavement Marking Material 1038
919.02 Spray Thermoplastic Pavement Marking Material 1042
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919.01 Thermoplastic Pavement Marking Material

Provide material conforming to AASHTO M 249, with the following additions.

A. Composition

Provide retroreflective pavement marking material of an alkyd/maleic based thermoplastic material consisting of homogeneously mixed pigments, filler, resins, and glass beads. Ensure that the pigment, beads, and filler are uniformly dispersed in the resin. The material shall be manufactured from virgin material using no reprocessed components.

Ensure that the material is free from all skins, dirt, and foreign objects, and conforms to the requirements specified in Table 919.01-1.

Table 919.01-1: Thermoplastic Pavement Marking Material

Component	White	Yellow
Binder, % minimum	19	19
TiO_2 Pigment, % minimum	10	N/A
Intermix Glass Beads, % minimum	35	35
Calcium Carbonate/Fillers, % maximum	36 (1)	46 (1)

(1) The amount of Calcium Carbonate and inert fillers shall be as recommended by the manufacturer, provided all other specifications are met.

Titanium dioxide shall be Rutile Type II, conforming to ASTM D476, with a minimum purity of 93%.

White thermoplastic shall not contain anatase titanium dioxide pigment.

The premixed beads shall constitute the total silica content used in the formulation of the thermoplastic. Uniformly disperse the pigment, beads, and filler in the binder.

The Alkyd/Maleic binder shall consist of a mixture of synthetic resins and high boiling point plasticizers, one of which shall be solid at room temperature. At least one-half of the binder composition, and no less than 15% of the entire material formulation, shall be 100% maleic modified glycerol ester of resin. Do not use a binder containing any petroleum, hydrocarbon resins, tall oil resins, or rosins.

Provide thermoplastic material meeting the following requirements:

1. The thermoplastic material shall be free of contaminates and shall be dry-blended or hot-mixed from 100% virgin stock using no reprocessed materials.

2. The thermoplastic material shall be formulated so that when it is on the roadway surface at any natural temperature, it will exist in a hard, solid state with cold ductility that allows normal movement with the road surface without chipping or cracking.

3. The thermoplastic shall not deteriorate or discolor when held at the application temperature for periods of time up to 4 hours or upon repeated reheating (a minimum of four times).

4. The color, viscosity, and chemical properties versus temperature characteristics of the thermoplastic material shall remain constant for up to 4 hours at the application temperature and shall be the same from batch to batch.

5. The thermoplastic material shall be readily applicable at temperatures between 400 °F and 440 °F from the approved equipment to produce lines and symbols of the specified thickness above the pavement surface.

B. Physical Requirements: After 4 hours @ 425 °F

Ensure that the thermoplastic material, after being heated for 4 hours ± 5 minutes at 425 ± 3 °F and cooled to 77 ± 3 °F, meets the physical requirements specified in AASHTO M 249, with the following changes.

Test the material in accordance with AASHTO T 250 and/or with the appropriate method in Federal Test Method Standard #141 or ASTM Designation.

1. **Safety.** No toxic fumes.

2. **Bond Strength.** 180 pounds per square inch, minimum, when tested in accordance with ASTM D4796.

3. **Specific Gravity.** Not to exceed 2.30.

4. **Yellowness Index.** The white thermoplastic shall not exceed a yellowness index of 0.15.

C. Glass Beads

Provide glass beads that meet AASHTO M 247.

Provide beads of clear, transparent, colorless glass, smooth and spherically shaped, free of milkiness, pits, or excessive air bubbles and that conform to the following specific requirements.

Use glass beads containing no more than 200 parts per million of lead or 200 parts per million of arsenic. Certify and ensure that all glass beads meet all Federal requirements. Provide an independent test report certifying that all glass beads contain no more than 200 parts per million of arsenic or lead as determined by a certified independent (third party) laboratory, in accordance with Environmental Protection Agency testing methods 3052, 6010B, or 6010C.

1. **Color and Clarity.** Beads shall be colorless, clear and free from carbon residues.

2. **Roundness.** Minimum true spheres overall shall be 80% when tested in accordance with ASTM D1155; for larger beads use visual inspection.

3. **Index of Refraction.** Minimum of 1.50, when tested by the liquid emersion method at 77 °F

4. **Air Inclusions.** Maximum of 3% overall.

D. Intermix Glass Beads

Premix glass beads into the thermoplastic mixture, to amount to 35% of the overall thermoplastic formulation. Use uncoated intermix beads defined by two distinct gradations and that meet the following requirements:

1. Type 1 Intermix glass beads shall make up at least 50% of 35% of the overall thermoplastic formulation (Intermix Glass Beads) and shall conform to AASHTO M 247, Type 1, with the exception that the minimum true spheres overall shall be 80% as specified in **919.01.C.2**.

2. Type 3 Intermix glass beads shall make up at least 50% of 35% of the overall thermoplastic formulation (Intermix Glass Beads) and shall conform to AASHTO M 247, Type 3 with the exception that the minimum true spheres overall shall be 80% as specified in **919.01.C.2**.

E. Double Drop System

The double drop system shall be capable of applying glass beads at the specified application rates. Apply beads across the entire line width, ensuring uniform application and embedment of the beads to 50 to 60% of the bead diameter.

Use Type 1 drop on beads that are dual-coated for moisture resistance and adhesion and that meet the requirements of AASHTO M 247 Type 1 with the exception that the beads shall be 80% round overall.

Use Type 4 drop on beads that are dual-coated for moisture resistance and adhesion and that meet the requirements of AASHTO M 247 Type 4 with the exception that the beads shall be 80% round overall.

919.02 Spray Thermoplastic Pavement Marking Material

A. Materials

1. General. Provide retroreflective pavement marking material that meets the requirements specified in **919.01**, with the following exceptions:

a. Spray thermoplastic pavement marking material shall conform to the requirements specified in Table 919.02-1.

Table 919.02-1: Spray Thermoplastic Pavement Marking Material

Component	White	Yellow
Binder, % min	26	26
TiO_2 Pigment, % min	10	N/A
Intermix Glass Beads, % min	35	35
Calcium Carbonate/Fillers, % max	29 (1)	29 (1)

(1) The amount of Calcium Carbonate and inert fillers shall be as recommended by the manufacturer, provided all other specifications are met.

b. Yellow thermoplastic shall contain no anatase titanium dioxide pigment.

c. Requirement **919.01.A.5** does not apply.

2. Glass Beads. Use beads conforming to AASHTO M 247, Type I.

3. Intermix Glass Beads. Premix glass beads for intermix into the thermoplastic mixture, to amount to 35% of the overall thermoplastic formulation.

4. Drop on Glass Beads. Use drop on glass beads that may be applied at the specified application rates and that are capable of flowing freely through dispensing equipment in any weather suitable for pavement marking application. Apply Type I beads at a minimum application rate of 10 pounds per 100 square feet. Apply beads across the entire line width, ensuring uniform application and embedment of the beads to 50 to 60% of the bead

diameter. Treat Type I drop on glass beads with a moisture resistant coating.

5. Marking Compound. Use material having the following characteristics:

a. In the molten state, the material shall not give off fumes that are toxic or otherwise injurious to persons or property. Obtain material safety data sheets for the product from the manufacturer.

b. The temperature versus viscosity characteristic of the plastic material shall remain constant. In addition, the material shall not deteriorate in any manner during three reheating processes.

c. No obvious change in material color shall occur as a result of up to three reheatings, or in maintaining the material at application temperature up to an aggregate time of 4 hours, or from batch to batch.

d. The maximum elapsed time after application at which normal traffic will leave no impression or imprint on the new stripe shall be 30 seconds when the air and road surface temperature is approximately 68 °F ± 5 °F.

e. The applied stripe 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.

f. The stripe shall maintain its original dimensions and placement.

g. Cold ductility of the material shall allow for normal dimensional distortion as a result of tall impact within the temperature range specified.

h. The material shall provide a stripe that has a uniform thickness throughout its cross-section.

B. Physical Requirements: After 4 Hours at 425 °F

Ensure that the thermoplastic material, after being heated for 4 hours ± 5 minutes at 425 ± 3 °F and cooled to 77 ± 3 °F, meets the physical requirements set forth in AASHTO M 249, with the following changes.

Test the material in accordance with AASHTO T 250.

1. Safety. No toxic fumes.

2. Flash Point. 500 °F minimum

3. Color. The marking compound, after being heated for 4 hours ± 5 minutes at 425 ± 3 °F and cooled to 77 ± 3 °F shall meet the following requirements for daylight reflectance and color, when tested using a color spectrophotometer with 45 degree circumferential /0 degree geometry, illuminant C, and 2 degree observer angle.

a. Daylight Reflectance (Y)

(1) White – 75% minimum

(2) Yellow – 42% minimum

b. Color. For yellow, meet Federal 595 Color No. 33538 and the chromaticity limits specified in Table 919.02-2.

Table 919.02-2: Chromaticity Coordinates

X	Y
0.470	0.455
0.510	0.485
0.485	0.425
0.530	0.456

4. Yellowness Index. The white marking compound shall not exceed a yellowness index of 0.12 when tested in accordance with ASTM D1925.

5. **Specific Gravity.** 2.0 maximum

6. **Softening Point.** After heating the marking compound for 4 hours ± 5 minutes at 425 ± 3 °F and testing in accordance with ASTM E28, the material shall have a minimum softening point of 180 °F as measured by the ring and ball method.

7. **Tensile Bond Strength.** After heating the marking compound for 4 hours ± 5 minutes at 425 ± 3 °F, the tensile bond strength shall exceed 180 pounds per square inch when tested in accordance with ASTM D4806. Apply the material to unprimed, sandblasted Portland cement concrete block at a thickness of 0.0625 inch and at a temperature of 375 ± 3 °F. Conduct the test at room temperature.

8. **Impact Resistance.** After heating the marking compound for 4 hours ± 5 minutes at 425 ± 3 °F, the impact resistance shall be a minimum of 50 inch-pounds when tested in accordance with ASTM D2794. No cracks or bond loss shall occur when a 0.0625-inch thick film drawdown is made at 375 F ± 3 °F on an unprimed sandblasted Portland cement concrete block. Test the sample with a 5/8-inch male indenter and no female die, at room temperature.

9. **Identification.** Ensure that each package of material is stenciled with the manufacturer's name, the type of material and specification number, the month and year the material was packaged, and the lot number. The letters and numbers used in the stencils shall be a minimum of 1/2 inch in height.

10. **Packaging.** Package the material in suitable containers that will not adhere to the product during shipment and storage. The container of pavement-marking material shall weigh approximately 50 pounds. Label each container with the color, binder (alkyd), spray, and user information, including the requirement to heat the material in the range of 350 to 425 °F.

11. **Storage Life.** The material shall meet the requirements of this specification for a period of one year. The material must also melt uniformly, with no evidence of skins or un-melted particles for this one-year period. Replace materials not meeting the specified requirements.

919.03 Preformed Plastic Pavement Marking Materials

Provide preformed plastic pavement marking material selected from the Department's QPL.

919.04 Raised Reflective Pavement Markers

Provide raised reflective pavement markers listed on the Department's QPL and classified as follows:

Type 1	One-Color, Reflective Markers (Two-way Traffic)
Type 2	One-Color, Reflective Markers (One-Way Traffic)
Type 3	Two-Color, Reflective Markers (One-way Traffic)

919.05 Snowplowable Reflective Pavement Markers

Provide reflectors consisting of an acrylic shell filled with tightly adherent potting compound. Select the potting compound based on strength, resilience, and adhesion adequate to pass the necessary physical requirements. The shell shall contain one or two reflective faces. Attach the reflector to an iron casting with an elastomeric pad.

Provide reflectors and castings selected from the Department's QPL and that conform to the following requirements.

A. Reflectors

1. **Dimensions.** Provide reflectors that are 4 ± 0.5 inches by 2.0 ±0.25 inches at the base, with a height of 0.40 inch or no higher than 0.50 inch. The slope of the reflector shall be 30 degrees, and the minimum area of the reflective surface shall be 1.87 square inches.

2. **Outer Surface.** Provide the shell with a smooth outer surface, except as needed for identification purposes.

3. **Base Surface.** Ensure that the base of the marker is substantially free from gloss or substances that may reduce its bond to adhesive.

Attach the markers, either mono- or bi-directional as specified, to an iron casting that is shaped to be snow plowable in the two opposing

longitudinal directions and designed to allow for removal and replacement when needed to restore reflectivity.

B. Castings

1. General. Provide casting that are 10 ± 0.5 inches long by 5.5 ± 0.5 inches wide. Ensure that the maximum projection of the casting above the roadway does not exceed 0.5 inch, and that snowplow blades will ride over the casting without contacting the reflective marker.

2. Casting Material. Provide castings of nodular iron conforming to ASTM A536, Grade 72-45-05, hardened to 52-54 RC.

3. Identification. Mark each casting with manufacturer's name and model number of marker.

SECTION 920 – EROSION CONTROL MATERIALS

920.01 Erosion Control Blankets 1048
920.02 Staples 1048

920.01 Erosion Control Blankets

Provide erosion control blankets selected from the Department's QPL.

920.02 Staples

Use wire not smaller than 11 gauge, formed into a U shape with legs at least 6 inches in length and a crown 1 inch in width. Ensure that staples have sufficient thickness to penetrate the soil without undue distortion.

SECTION 921 – MISCELLANEOUS MATERIALS

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921.01 Water

For mixing concrete, use water that is reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable matter, and other substances injurious to the finished product. Test water in accordance with AASHTO T 26. The Contractor may use water known to be of potable quality without testing. Where the source of water is relatively shallow, enclose the intake so as to exclude silt, mud, grass, and other foreign materials.

921.02 Calcium Chloride

A. Solid Form

Provide solid forms of calcium chloride conforming to the requirements of AASHTO M 144, for the type specified, except that the Department

will waive requirements for total alkali chlorides and impurities when calcium chloride is to be used in mineral aggregate base or surface courses.

B. Liquid Form

Provide liquid forms of calcium chloride consisting of a clear liquid free from suspended matter and that meets the requirements specified in Table 921.02-1.

Table 921.02-1: Calcium Chloride Liquor

Component	Concentration of Calcium Chloride Liquor	
	32%	38%
Total Calcium Chloride by Weight, min.	32	38
Total Magnesium Chloride by Weight, max.	0.5	0.5

Do not use a calcium chloride solution of less than 32%.

Include with each shipment of calcium chloride liquor a certification from the manufacturer that states the concentration and new weight, and guarantees the percentage of calcium chloride.

921.03 Sodium Chloride

Provide sodium chloride conforming to ASTM D632, for the type specified.

921.04 Lime

Provide lime conforming to the requirements of ASTM C977, for the type specified.

921.05 Select Material for Soil-Cement Base

Provide select material for soil-cement base of such general character as to be classified as Group A-1 or A-2, in accordance with AASHTO M 145, and of such size that all will pass the standard 1-1/2 inch sieve.

921.06 Chemical Additives

A. Admixtures

1. **Portland Cement Concrete Mixtures.** Provide additives that are listed on the QPL and conform to AASHTO M 194 for the following seven types of admixtures:

   Type A - Water reducing admixtures
   Type B - Retarding admixtures
   Type C - Accelerating admixtures
   Type D - Water-reducing and retarding admixtures
   Type E - Water-reducing and accelerating admixtures
   Type F - Water-reducing, high range admixtures
   Type G - Water-reducing, high range admixtures and retarding admixtures
   Type S - Specific performance admixtures

   Before the Department will approve any admixture for use in Portland cement concrete mixtures under these Specifications, either the manufacturer of the admixture or the Contractor shall furnish the Department documentary evidence that the material proposed for use has been tested in accordance with the test methods in AASHTO M 194 and meets the requirements of that specification. Documentary evidence shall include the results of tests conducted by a testing laboratory inspected at regular intervals by the National Bureau of Standards and approved by the Department. The Department may require a notarized certification from the manufacturer stating that the material is identical to that originally approved and has in no way been changed or altered.

2. **Air-Entraining Admixtures.** Use air-entraining admixtures that are listed on the Department's QPL and conform to AASHTO M 154, except that the tests for bleeding, bond strength, and volume change will not be required.

   The Department may approve a product if the manufacturer or Contractor furnishes test data from a recognized laboratory showing that the air-entraining admixture proposed for use conforms to the requirements of these Specifications. A recognized laboratory is defined as one of the following: A State Transportation Department Laboratory; a Federal Highway Administration Laboratory; or other laboratories that are regularly

inspected by the Cement and Concrete Reference Laboratory and approved by the Department.

B. Bituminous Additives

1. **Anti-Stripping Additive.** Use hydrated lime conforming to ASTM C977 or other heat-stable asphalt anti-stripping additive containing no ingredient harmful to the bituminous material or the workmen and that does not appreciably alter the specified characteristics of the bituminous material when added in the recommended proportions.

   When hydrated lime is the anti-stripping additive, use an amount equal to 1% by weight of the aggregate. Uniformly coat the aggregate with the lime, to the Engineer's satisfaction, before adding the bituminous material to the mixture.

   When using an anti-stripping additive other than hydrated lime, the percentage of anti-stripping additive used shall range between 0.3% to 0.5% by weight of the asphalt cement.

   The Department's QPL identifies qualified antistripping products. Do not use any product unless it appears on this list.

2. **Silicone Additives.** Mix silicone additives at the rate of 1 pint of silicone per 4 gallons of diesel fuel. The Contractor may use a 1/2 pint of this mixture per 1,000 gallons of asphalt.

3. **Warm Mix Asphalt (WMA) Additives.** The Contractor may add organic wax or foaming additives to bituminous plant mix to reduce placement temperatures as specified in **407.11**. Introduce the WMA additives into the mixture at a constant rate, sufficient to produce the mix temperatures specified in **407.11**, and in a manner approved by the Department. Record all changes to the proportions of the additive used during the course of mix production. The Department's QPL identifies qualified WMA additives. Only use additives appearing on this list.

921.07 Masonry Stone

Provide sound, dense, and durable masonry stone, free from excessive cracks, pyrite intrusions, and other structural defects. Ensure that stones

that will be used with mortar are free from dirt, oil, or other material that might prevent good adhesion with the mortar.

When the crushed aggregate is subjected to five alternations of the sodium sulfate soundness test, the weighted percentage of loss shall be not more than 12.

921.08 Waterstops

Provide waterstops of the type, shape, and dimensions shown on the Plans.

A. Metallic

Provide metallic waterstops of sheet copper conforming to the requirements of **908.13**.

B. Nonmetallic

Provide nonmetallic waterstops, manufactured from natural rubber, synthetic rubber, or polyvinyl chloride (PVC), that are dense, homogeneous, and free from holes and other imperfections. The cross-section of the waterstop shall be uniform along its length and transversely symmetrical so that the thickness at any given distance from either edge of the waterstop will be uniform.

Fabricate rubber waterstops from a high grade thread-type compound, consisting of not less than 70% by volume of the basic polymer, with the remainder composed of reinforcing carbon black, zinc oxide, accelerators, anti-oxidants, vulcanizing agents, and plasticizers. The compound shall contain no factice. As the basic polymer, use natural rubber or a co-polymer of butadiene and styrene, or a blend of both.

Samples taken from the finished waterstop shall meet the requirements specified in Table 921.08-1.

Table 921.08-1: Requirements for Nonmetallic Waterstops

Property	ASTM Test Method	Value
Tensile Strength (Die "C")	D412	2,500 psi, min
Ultimate Elongation (Die "C")	D412	450%, min
Shore Durometer Hardness	D2240	60-70
Specific Gravity	D297 (Section 17)	1.15 ± 0.03
Water Absorption (% by weight)	D570	5%, max
Tensile strength after accelerated aging, oxygen-pressure method	D572	80%, min

C. Polyvinyl Chloride (PVC) Waterstop

Provide waterstops extruded from an elastomeric plastic compound, the basic resin of which shall be PVC. The compound shall contain additional resins, plasticizers, stabilizers, or other materials needed to ensure that when the material is compounded it will meet the performance requirements specified in Table 921.08-2. Do not use any reclaimed PVC.

Table 921.08-2: Requirements for PVC Waterstops

Property	Test Method	Value
Tensile Strength (Die "C")		
Sheet Material	ASTM D412	2,000 psi, min
Finished Waterstop	ASTM D412	1,700 psi, min
Ultimate Elongation (Die "C")		
Sheet Material	ASTM D412	350%, min
Finished Waterstop	ASTM D412	300%, min
Stiffness in Flexure	ASTM D747	750 psi, min
Accelerated Extraction	CRD-C 572	
Tensile Strength (Die "C")	ASTM D412	1,750 psi
Elongation (Die "C")	ASTM D412	300%
Effect of Alkali (after 7 days)	CRD-C 572	
Change in Weight		-0.1 to + 0.25%
Change in Hardness, Shore Durometer		± 5%
Low Temperature Brittleness	ASTM D746	-35 °F
Specific Gravity	ASTM D792	1.3

For PVC waterstops, the supplier shall submit a certificate stating that all of the performance requirements specified above for the sheet material have been complied with. In addition, the supplier shall submit an affidavit to the effect that the sheet sample is of the same material in all respects as that to be used in the manufacture of the finished waterstop. The supplier shall also specify the value of the specific gravity of the finished waterstop material to within plus or minus 0.02.

Manufacture waterstops with an integral cross-section, uniform within plus or minus 1/8 inch in width, and with the web thickness or bulb diameter within plus 1/16 inch and minus 1/32 inch.

Furnish the Department a certified test report from an approved laboratory covering each lot or unit of finished waterstops and containing the numerical laboratory test data of all required tests.

921.09 Grout

Mix grout in small quantities as needed, and do not retemper or use grout after it has begun to set. Unless otherwise specified or directed, provide grout consisting of one part Portland cement and two parts sand by volume, mixed with sufficient water to form a grout of proper consistency. Use Portland cement conforming to the requirements of **901.01**, and sand conforming to the requirements of **903.02**. Use water that has been approved by the Engineer.

When non-shrinking or non-shrinking fast-setting grout is specified, either formulate it by incorporating an admixture, or use a pre-mixed grout. Obtain the Engineer's approval of the formulation and the admixture or the premixed grout. Mix and use the grout in accordance with the manufacturer's recommendations. These special grouts will be classified as follows:

Type I - Non-shrinking Grout

Type II - Non-shrinking, Fast-setting Grout

921.10 Precast Manholes and Catch Basins

Provide precast manholes and catch basins that conform to ASTM C478 and that are made in accordance with the Department's procedure for the Manufacture and Acceptance of Precast Drainage Structures, Noise Wall Panels, and Retaining Wall Panels.

921.11 Manhole Steps

For use in manholes or catch basins, provide steps meeting ASTM C478, Article 11.2.1, or that are of the design shown on the Plans.

Provide cast iron steps conforming to **908.07**.

Provide aluminum steps fabricated from aluminum Alloy 6061, T6, with a minimum tensile strength of 38,000 pounds per square inch, a minimum yield strength of 35,000 pounds per square inch, and an elongation in 2 inches of not less than 10%.

921.12 Geotextile and Geosynthetic Material

Provide geotextiles and geosynthetics listed on the Department's QPL and that meet the material requirements shown on the Standard Drawing.

Furnish, with each shipment of materials, a certified laboratory test report from an approved testing laboratory and a certified letter stating the product provided is the same as on the Department's QPL. Laboratory test reports shall include the actual numerical test data obtained. Clearly label all rolls as being part of the same production run from which the test data was derived.

Protect geosynthetics to prevent damage during transportation, storage, and installation. Store geotextile and geosynthetic rolls elevated up off of the ground and covered to protect against UV degradation. Do not install material that is torn, punctured, or otherwise damaged.

921.13 Precast Prestressed Bridge Deck Panels

Construct and inspect the precast prestressed deck panels in accordance with the Plans, approved shop drawings, and the Standard Specifications. Fabricate the panels in a plant certified by the Precast/Prestressed Concrete Institute (PCI) category B-3.

Cast panels on beds that are clean, straight, level, and in good repair. Bulkheads and headers are to be of the size and configuration to adequately hold cables in place during casting operations. Keep forms, headers, cables, reinforcing bars or other steel that comes in contact with freshly placed concrete below 90 °F during casting operations. Cover and cure freshly cast panels as specified in **615.11**.

Provide projecting bars or other hardware for lifting and handling panels at the locations and in accordance with the details shown on the approved Shop Drawings. Protect projecting bars against impact and ensure that they are not bent in the shop, during handling and transporting, or in the field. Protect panels from damage during lifting, storing, and transporting.

Repair small damaged or isolated honeycombed areas that are purely surface in nature and not over 1 inches in depth at the fabrication plant with an approved epoxy grout. Replace panels with more extensive damage or honeycomb.

Inspect the panels at the point of delivery to the jobsite for identification, dimensional tolerances, cracks, and structural damage. Replace panels exhibiting excessive cracking or other structural damage.

Replace panels having any of the following defects:

1. Any crack that comes within 1 inches of a strand.

2. Corner cracks or breaks that involve one strand.

3. Isolated damage or honeycomb larger than approximately 6 inches in diameter or length and 1 inch in depth that involves one strand.

In evaluating for the above defects, consider a crack as a fissure of any length that extends from the surface of the panel to the mid-depth of the panel or to a strand, in accordance with any of the following conditions:

1. The crack is visible at the ends or edges of the panel.

2. The strand is visible within the crack.

3. The crack can be probed to mid-depth or to the strand.

4. The crack is visible on the top and bottom surface of the panel at approximately the same relative location.

Any new crack that appears in a panel after the deck is poured will be considered to extend to the mid-depth of the panel or to a strand. Replace, or repair to the Engineer's satisfaction, panels exhibiting new cracks after the slab is poured.

Defects not covered by the above will be subject to review by the Engineer.

921.14 Applied Textured Finish Material

The material for applied textured finish shall meet the requirements of Federal Specifications TT-C-00555, Type II, except as modified below:

A. Freeze-Thaw Test

1. Cast and cure three concrete specimens, not less than 4 x 6 x 6 inches, of a mix designed for structures. Moist cure for

14 days with a drying period in room air at 60 to 80 °F for 24 hours before coating with spray finish. Take caution to ensure that no excessive oil forms on specimen. Coat sides of specimens (brush permitted) and cure at room temperature for 48 hours; after which:

2. Immerse the specimen in water at room temperature (60 to 80 °F) for 3 hours; remove and,

3. Place in cold storage at -15 °F for 1 hour; remove and,

4. Thaw at room temperature (60 to 80 °F) for 1 hour.

5. Repeat Steps 3 and 4 to complete a total of 50 cycles.

B. Exposure Test

Subject the material to a 5,000-hour exposure test conforming to ASTM G155, operating a xenon arc light apparatus for non-metallic materials. At the end of the exposure test, the exposed sample shall not show any chipping, flaking, or peeling.

C. Fungus Growth Resistance

Material to be used must pass a fungus resistance test as described by Federal Specification TT-P-29b with a minimum incubation period of 21 days. There shall be no indication of growth after the test.

Submit to the Materials and Tests Engineer a 1-quart sample of the material proposed for use. This material will be tested and placed on the Department's QPL if it meets specifications.

After the material has been initially qualified and placed on the QPL, submit for each project on which the material is used, a certified statement from the formulator stating that the material furnished is identical in all respects to that which was initially qualified.

The Department reserves the right to require samples and to perform any or all of the tests specified.

921.15 Fly Ash

Use fly ash meeting AASHTO M 295, Class F or Class C, for the class specified. Do not use fly ash of different classes or sources as a partial cement replacement in Type I Portland cement concrete on the same project.

Provide fly ash meeting the requirements specified in Table 921.15-1.

Table 921.15-1: Fly Ash Requirements

Property	Fly Ash Class	
	F	**C**
A. Chemical Requirements: Uniformity Requirements		
The loss on ignition of individual samples shall not vary from the average established by the 10 preceding tests, or by all preceding tests if the number is less than 10, by more than: Loss on ignition, max variation, percentage points from average	1.0	1.0
B. Physical Requirements: Pozzolanic Activity Index		
With Portland cement, at 7 days, min, % of control	60	60
With Portland cement, at 7 days, min, % of control	75	75

Obtain fly ash from an approved source as shown on the Department's QPL.

921.16 Ground Granulated Blast Furnace Slag

Provide ground granulated blast furnace slag meeting the requirements of AASHTO M 302, Grade 100 or Grade 120. Do not use ground granulated blast furnace slag of different grades or sources as a partial cement replacement in Type I Portland cement concrete on the same project.

Obtain ground granulated blast furnace slag from an approved source as shown on the Department's QPL.

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