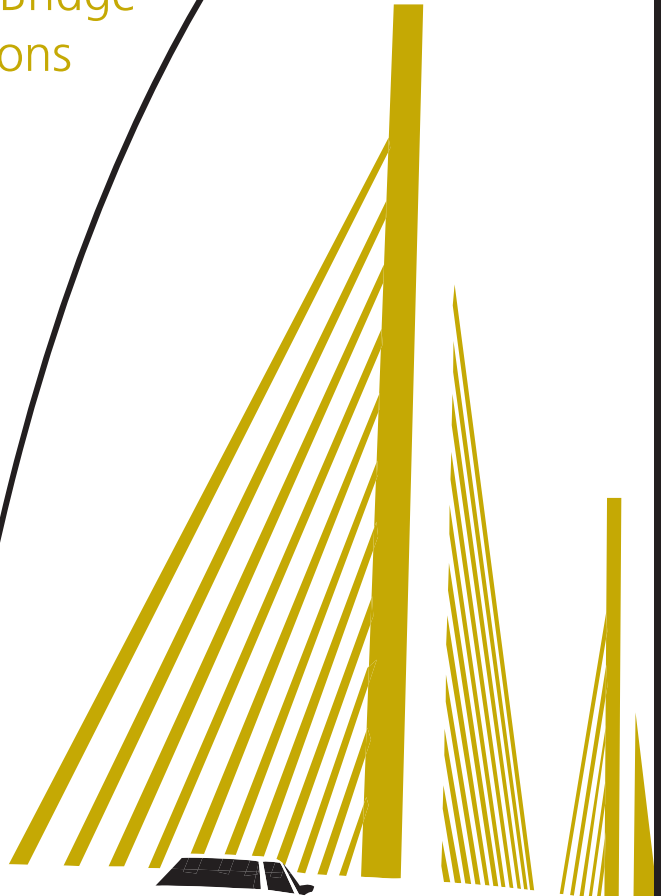


2007

Road and Bridge
Specifications



VDOT Virginia Department
of Transportation

2007

Road and Bridge
Specifications



VDOT Virginia Department
of Transportation

INTRODUCTION

These Road and Bridge Specifications are standard for all contracts awarded by the Commonwealth Transportation Board or the Commissioner. The requirements stated herein may be revised or amended from time to time but only to the extent permitted under supplemental specifications, special provisions and special provision copied notes included in the specific contract.

Reference by date and title will be made to these Specifications on plans and other contract documents as notification of their application to those documents. Copies of these Specifications may be obtained from the office of the Contract Engineer at 1401 E. Broad Street, Richmond, Virginia 23219.

Malcolm T. Kerley, P.E.
Chief Engineer

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Division I
GENERAL PROVISIONS

**SECTION 101—DEFINITIONS OF ABBREVIATIONS,
ACRONYMS, AND TERMS**

101.01—Abbreviations and Acronyms

In these Specifications and other Contract Documents, the following abbreviations and acronyms shall be interpreted as follows:

AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
ABS	Acrylonitrilebutadienestyrene (an elastomer)
AC	Alternating current
ACI	American Concrete Institute
ADT	Annual average daily traffic
AED	Associated Equipment Distributors
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
APA	Engineered Wood Association
API	American Petroleum Institute; American Pipe Institute
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWG	American wire gage
AWPA	American Wood Preservers Association
AWS	American Welding Society
AWWA	American Water Works Association
BOCA	Building Officials and Code Administrators
C	Celsius, when preceded by “degree(s)”
CABB	Contractor Advertisement Bulletin Board
CBR	California bearing ratio
CRSI	Concrete Reinforcing Steel Institute
DBE	Disadvantaged Business Enterprise
DC	Direct current
DHV	Design hourly volume
EEl	Edison Electric Institute
EEO	Equal employment opportunity
EIA	Electronic Industries Alliance
EPA	Environmental Protection Agency
EPDM	Ethylenepropylenedienemonomer (an elastomer)
ESCCC	Erosion and Sediment Control Contractor Certification
F	Fahrenheit, when preceded by “degree(s)”
F/A	Filler/asphalt ratio
FHWA	Federal Highway Administration
FS	Federal Specifications, General Services Administration
ICEA	Insulated Cable Engineers Association
IMSA	International Municipal Signal Association
ITE	Institute of Transportation Engineers
LCD	Liquid crystal display
LPG	Liquid petroleum gas

101.01

MBE	Minority Business Enterprise
MEKP	Methyl ethyl ketone peroxide
MIL	Military specifications
MSDS	Materials Safety Data Sheet
MUTCD	<i>Manual on Uniform Traffic Control Devices for Streets and Highways</i> and the Virginia supplement to same
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NRC	Nuclear Regulatory Commission
PCI	Precast / Prestressed Concrete Institute
PE	Polyethylene
PTL	Plywood Testing Laboratory
PVC	Polyvinylchloride
PVF	Polyvinylfluoride
SAE	Society of Automotive Engineers
SP	Special Provision
SPCN	Special Provision Copied Note
SPIB	Southern Pine Inspection Bureau
SSPC	Society for Protective Coatings
SWPPP	Storm Water Pollution Prevention Plan
TAPPI	Technical Association of the Pulp and Paper Industry
TFE	Polytetrafluoroethylene
TIE	Ticket Information Exchange (Miss Utility)
UL	Underwriters' Laboratories, Inc.
VAC	Volts alternating current
VDC	Volts direct current
VDOT	Virginia Department of Transportation
VEP	Value engineering proposal
VFA	Voids filled with asphalt
VMA	Voids in mineral aggregate
VOSH	Virginia Occupational Safety and Health
VTM	Virginia Test Methods; voids in total mix
VWAPM	Virginia Work Area Protection Manual
WBE	Women Business Enterprise

101.02—Terms

In these Specifications and other Contract Documents, the following terms and pronouns used in place of them shall be interpreted as follows:

–A–

Advertisement, Notice of. A public announcement, as required by law, inviting bids for work to be performed or materials to be furnished that indicates approximate principal quantities, location of work to be performed, character and quantity of materials to be furnished, and time and place for opening bids.

Affiliate. Any business entity that is closely associated to another business entity so that one has the power to control the other either directly or indirectly; or, where one business entity systematically shares resources, officers and/or other management with another business entity to the extent that a business relationship legally exists or is publicly perceived to exist; or, when a third party has the power to control both; or, where one business entity has been so closely allied with another through an established course of dealings, including but not limited to the lending of financial wherewithal or engaging in joint ventures, so as to cause a public perception that the two firms are one entity.

Alkali soil. Soil in which total alkali chlorides calculated as sodium chloride are more than 0.10 percent based on total solids.

Award. The decision of the Board or Commissioner to accept the bid of the lowest responsive and responsible bidder for the work. The award is subject to the execution and approval of a satisfactory Contract therefor, and such conditions as may be specified or required by law.

Award date. The date on which the decision is made by the Board or Commissioner to accept the bid of the lowest responsive and responsible bidder.

–B–

Backfill. Material used to replace or the act of replacing material removed during construction; may also denote material placed or the act of placing material adjacent to structures.

Balance point. The approximate point, based on estimated shrinkage or swell, where the quantity of earthwork excavation and borrow, if required, is equal to the quantity of embankment material plus any surplus excavation material.

Base course. A layer of material of specified thickness on which the intermediate or surface course is placed.

Base flood. The flood or tide having a one percent chance of being exceeded in any given year.

Bid. The offer of a bidder, submitted by electronic proposal (or on paper if so specified in the proposal) to perform the work and furnish the materials and labor at the prices set forth therein; valid only when properly signed and guaranteed.

Bidder. Any individual, partnership, corporation, or joint venture that formally submits a bid for the work contemplated, or for any portion thereof, acting directly or through a duly authorized representative.

Bids, Invitation for. See **Advertisement, Notice of.**

Board. Commonwealth Transportation Board.

Borrow. Suitable material not available from designated Regular Excavation or other sources of useable materials on-site that is used primarily for embankment.

Brackish water. Water in which total alkali chlorides calculated as sodium chloride are more than 0.10 percent based on total solids.

Bridge. A structure, including supports, that is erected over a depression or an obstruction, such as water, a highway, or a railway, that has a track or passageway for carrying traffic.

Bridge lift. A layer of fill material placed in excess of standard depth over an area that does not support the weight of hauling equipment and for which compaction effort is not required.

–C–

Calendar day. Any day shown on the calendar.

Camber. A vertical curvature induced or fabricated into beams or girders and a deck slab or slab span formwork; a vertical curvature set in the grade line of a pipe culvert to accommodate differential settlement.

Channel. A watercourse or drainage way.

Commissioner. Commonwealth Transportation Commissioner.

Commonwealth. Commonwealth of Virginia.

Composite hydrograph. A graph showing the mean daily discharge versus the calendar day, indicating trends in high and low flow for a one-year period.

Construction area. The area where authorized construction occurs.

Construction limits (On-Site). The disturbed area required for the construction of a Project including the intersection of side slopes, with the original ground, plus slope rounding and slopes for drainage ditches, bridges, culverts, channels, temporary or incidental construction, and identified by the surface planes as shown and/or described within the Contract Documents.

Contract. The written agreement executed between the Department and the Contractor that sets forth the obligations of the parties thereunder, including, but not limited to, the performance of the work, furnishing of materials and labor, and the method of measurement and basis of payment of the work, as identified in the Contract Documents.

Contract Documents. The edition of the *Road and Bridge Specifications* cited in the Bid Proposal and Contract, which include addenda or Revisions issued prior to the Bid Date, the Supplemental Specifications, Special Provisions, Special Provision Copied Notes, the Plans, the Edition of the *Road and Bridge Standard Drawings* cited on the title sheet of the plans which include Addendum's or Revisions issued prior to the Bid Date, Change Orders and/or Work Orders issued subsequent to the Contract Execution date and Written Directives, Agreements or Clarification. Oral representations or promises will not be considered a part of the Contract.

Contract item. A specifically described unit of work for which a price is provided in the Contract.

Contract time limit. The number of calendar days or fixed calendar date or that specifies the time allowed for completion of the work described in the Contract, including authorized extensions.

Contractor. Any individual, partnership, corporation, or joint venture that contracts with the Department to perform the prescribed work as an independent contractor and not as an agent for the Department, Commissioner or Commonwealth Transportation Board.

Corporation. A body of persons granted a charter legally to conduct business recognizing them as a separate entity having its own rights, privileges, and liabilities distinct from those of its members.

Cul-de-sac. An area at the terminus of a dead-end street or road that is constructed for the purpose of allowing vehicles to turn around.

Culvert. A structure that is not classified as a bridge which provides an opening under any roadway.

Cut. When used as a noun with reference to earthwork, that portion of a roadway formed by excavating below the existing surface of the earth and limited by design or the direction of the Engineer.

Cut Slope. See also Fill Slope. A surface plane generally designated by design or the direction of the Engineer which is formed during excavation below existing ground elevations that intersects with existing ground at its termini.

–D–

Day. Unless otherwise stated, a calendar day.

Deflection. The vertical movement occurring between the supports of a bridge superstructure or its components (beams, girders, and slabs) that results from their own weight and from dead and live loads. Although all parts of a structure are subject to deflections, usually only those deflections that occur in the superstructure are of significance during construction.

Department. Virginia Department of Transportation.

Design flood. The magnitude of flood that a given structure can convey without exceeding a designated flood level.

Digital Identification (I.D.). An encrypted signature that is the legal equivalent of a written signature thus allowing for the digital signing of the bid.

Disincentive. A verifiable monetary deterrent used to discourage the Contractor from failing to meet a contract milestone and/or the contract time limit that is identified and defined by specific Contract language.~

Disposable material. Material generally found to be unsuitable for roadway construction or material that is surplus.

Disposal areas. Areas generally located outside of the Construction Limits identified in the Contract Documents where unsuitable or surplus material is deposited.

Drainage ditch. An artificial depression constructed to carry off surface water.

–E–

Earthwork. The work consisting of constructing roadway earthwork in conformity with the specified tolerances for the lines, grades, typical sections, and cross sections shown on the plans or as established by the Engineer. Earthwork shall include regular, borrow, undercut and minor structure excavation; constructing embankments; disposing of surplus and unsuitable material; shaping; grading, compaction; sloping; dressing; and temporary erosion control work.

Easement (Right of way). A grant of the right to use property for a specific use.

Embankment. A structure of soil, soil aggregate, soil-like materials, or broken rock between the existing ground and subgrade.

Employee. Any person working on the project specified in the Contract who is under the direction or control of or receives compensation from the Contractor or subcontractor.

Engineer. The Chief Engineer, as designated by the Commonwealth Transportation Commissioner, who acts directly or through his duly authorized representative(s) and who is responsible for highway design, construction, and maintenance. The Engineer, or his representative(s), acts within the scope of the particular duties assigned to him or the authority given to him by the Code of Virginia, the Commonwealth Transportation Commissioner, these Specifications, supplemental specifications, and the Contract Documents.

Engineer, Contract. The Chief Engineer's authorized representative for administering the advertisement of work, receiving bids for such , and awarding such work as contracts for the Department.

Equipment. Machinery, tools, and other apparatus, together with the necessary supplies for upkeep and maintenance, that are necessary for acceptable completion of the work.

Excavation (Excavate). The act of creating a man-made cavity in the existing soil for the removal of material necessary to obtain a specific elevation or to install a structure, material, component or item necessary to complete a specific task or form a final surface or subsurface.

Execution date. The date on which the contract is signed by the Chief Engineer.

Extra work. An item of work that was not provided for in the Contract as awarded but that is found to be essential to the satisfactory fulfillment of the Contract within its intended scope and is identified in a written authorized Work Order or Force Account directive for its execution subject to the limitations, exceptions and provisions in Sections 104.02 and 104.03 and 109.05.

–F–

Falsework. A temporary framework used to support work in the process of constructing permanent structural units.

Federal agencies or officers. An agency or officer of the federal government and any agency or officer succeeding in accordance with the law to the powers, duties, jurisdictions, and authority of the agency or officer mentioned.

Fill Slope. See also Cut Slope. A surface plane formed during embankment above existing ground elevations that intersects with existing ground at its termini.

Firm. A commercial partnership of two or more persons formed for the purpose of transacting business.

Flood frequency. A statistical average recurrence interval of floods of a given magnitude.

Force account work. Prescribed work of a contractual status performed by the Contractor and compensated for as specified in Section 109.05. A Force Account agreement is made with the Contractor

when neither the Engineer nor the Contractor can firmly establish an applicable estimate for the cost of the work, because the scope of the work is not defined or quantifiable at the time of discovery or start of execution. Force account is used when what is to be done is known, but the level of effort or quantity of materials that will be necessary to accomplish that task is unknown but will be determined as the work progresses. In these cases the rates for the labor, equipment, and materials to be used are agreed upon in advance, and daily records are kept by the Engineer in order to track the eligible expenditures.

Formwork. A temporary structure or mold used to retain the plastic or fluid concrete in its designated shape until it hardens. Formwork shall be designed to resist the fluid pressure exerted by plastic concrete and additional fluid pressure generated by vibration and temporary construction loads.

Frontage street or road. A local street or road auxiliary to and located on the side of a highway for service to abutting property and adjacent areas and control of access.

–G–

Gage. U.S. Standard Gage.

Grade separation. Any structure that provides a traveled way over or under another traveled way or over a body of water.

–H–

Highway. The entire right of way reserved for use in constructing or maintaining the roadway and its appurtenances.

Historical flood level. The highest flood level that is known to have occurred at a given location.

Holidays. The days specifically set forth in Section 108.02 or in the Contract Documents.

Hydrologic data sheet. A tabulation of hydrologic data for facilities conveying a 100-year discharge equal to or greater than 500 cubic feet per second.

–I–

Incentive. A verifiable monetary amount used to encourage the Contractor to complete work prior to the milestone dates and/or the time limit specified in the Contract.

Inspector. The Engineer's authorized representative who is assigned to make detailed inspections of the quality and quantity of the work and its conformance to the requirements and provisions of the Contract.

Invert. The lowest point in the internal cross-section of a pipe or other drainage structure.

–J–K–

Joint venture. Two or more individuals, partnerships, corporations, or combinations thereof that join together for the purpose of bidding on and constructing a project.

-L-

Laboratory. The testing laboratory of the Department or any other testing laboratory that may be designated by provisions in the Contract or by the Engineer.

Liquidated damages. Compensatory damages as set forth in the Contract, paid by the Contractor to the Department when the Contractor fails to complete the project within the time frame specified in the Contract. These damages include, but are not limited to, additional costs associated with administration, engineering, supervision and inspection of the project.

-M-

Major Item. Any pay item specifically indicated as such in the Contract Documents.

Material. Any substance that is used in the work specified in the Contract

Median. The portion of a divided highway that separates the traveled ways.

-N-

Non-Contract item. Item(s) of work that is required to permit completion of the specified work in an acceptable manner, located within the Limits of Construction, but is not included in the Contract Documents and will be completed by others prior to or during the construction of the Project.

No Plan and Minimum Plan Concept project. Generally a project of very limited scope and duration that requires few details to describe the proposed work,

Notice to Proceed. The date of contract execution or a specified date identified as such and set forth in the Contract Documents on which the Contractor may begin the work.

-O-

Ordinary high water. A water elevation based on analysis of all daily high waters that will be exceeded approximately 25 percent of the time during any 12 month period.

Overtopping flood. The magnitude of flood that just overflows the traveled way at a given structure and/or on the approach traveled way of such structure.

-P-Q-

Pavement structure. The combination of select or stabilized materials, subbase, base, and surface courses, described in the Typical Pavement Section in the Plans that is placed on a subgrade to support the traffic load and distribute it to the roadbed.

Pay item. A specifically described unit of work for which a price is provided in the Contract.

Phase inspection. The inspection of work at predetermined stages in lieu of continuous inspection.

Plans. The approved project plans and profiles, which may include Standard Drawings, survey data, typical sections, summaries, general notes, details, plan and profile views, cross-sections, special design drawings, computer output listings, supplemental drawings or exact reproductions thereof, and

all subsequently approved revisions thereto which show the location, character, dimensions, and details of the work specified in the Contract

Prequalification. The procedure used by the Department to assure itself of the Contractor's ability to perform the work with attention to quality and safety including his experience in similar work, and sufficiency of equipment to accomplish the work and that the Contractor's financial resources will permit financing the cost in accordance with the Rules Governing Prequalification Privileges.

Profile grade. The line of a vertical plane intersecting the top surface of the proposed wearing surface, usually along the longitudinal centerline of the roadbed.

Project. The total scope of work specified to be performed in the Contract Documents.

Project showing. The scheduled event at which the Department's representative meets with prospective bidders to describe and answer questions regarding the proposed work.

Proposal: The document provided by the Department to prospective bidders or personally obtained by prospective bidders that describes the work for which bids will be accepted which includes the electronic forms on which the Department requires bids to be submitted for the work described.

–R–

Ramp. A connecting roadway between two highways or traveled ways or between two intersecting highways at a grade separation.

Right of way. A general term denoting land, property, or interest therein, usually in the form of a strip, that is acquired for or devoted to transportation facilities but is not meant to denote the legal nature of ownership.

Road. A general term denoting a public way for purposes of vehicular travel including the entire area within the right of way; the entire area reserved for use in constructing or maintaining the roadway and its appurtenances.

Road and Bridge Specifications. The specifications contained herein and generally recognized as the standard specifications for all contracts awarded by the Commonwealth Transportation Board or the Transportation Commissioner.

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

Roadbed material. The material below the subgrade in cuts, embankments, and embankment foundations that extends to a depth and width that affects the support of the pavement structure.

Roadside. A general term that denotes the area within the right of way that adjoins the outer edges of the roadway; extensive areas between the roadways of a divided highway.

Roadside development. Items that are necessary to complete a highway that provide for the preservation of landscape materials and features; rehabilitation and protection against erosion of areas disturbed by construction through placing seed, sod, mulch, and other ground covers; and such suitable plantings and other improvements as may increase the effectiveness, service life and enhance the appearance of the highway.

Roadway. The portion of a highway within the limits of construction and all structures, ditches, channels, and waterways which are necessary for the correct drainage thereof.

–S–

Seawater. Water in which total alkali chlorides calculated as sodium chloride are more than 0.10 percent of total solids.

Select borrow. Borrow material that has specified physical characteristics.

Select material. Material obtained from roadway cuts, borrow areas, or commercial sources that is designated or reserved for use as a foundation for the subbase, subbase material, shoulder surfacing, or other specified purposes designated in the Contract Documents.

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

Sidewalk. The portion of the roadway constructed primarily for the use of pedestrians.

Skew. The acute angle formed by the intersection of a line normal to the centerline of the roadway with a line parallel to the face of the abutments or, in the case of culverts, with the centerline of the culverts.

Special Provision (SP). A document that sets forth specifications or requirements for a particular project that is not covered by the standard Specifications.

Special Provision Copied Note (SPCN). A document that sets forth specific specifications or requirements, usually limited in scope, for a particular project.

Specialty item. An item of work designated as “Specialty Item” in the proposal that is limited to work that requires highly specialized knowledge, craftsmanship, or equipment that is not ordinarily available in contracting organizations prequalified to bid and is usually limited to minor components of the overall Contract.

Specifications. A general term that includes all directions, provisions, and requirements contained herein and those that may be added or adopted as supplemental specifications, special provisions, or special provision copied notes. All are necessary for the proper fulfillment of the Contract.

Standard drawings. Unless otherwise specified, applicable drawings in the Department’s *Road and Bridge Standards* and such other standard drawings as are referred to on the plans.

State. Commonwealth of Virginia.

Station. When used as a definition or term of measurement, 100 linear feet.

Street. A general term denoting a public way for purposes of vehicular travel including the entire area within the right of way; the entire right of way reserved for use in constructing or maintaining the roadway and its appurtenances.

Structures. Bridges, culverts, catch basins, inlets, retaining walls, cribs, manholes, end walls, buildings, steps, fences, sewers, service pipes, underdrains, foundation drains, and other features that may be encountered in the work and are not otherwise classed herein.

Subbase. A layer(s) of specified or selected material of designed thickness that is placed on a subgrade to support a base course.

Subcontractor. Any individual, partnership, corporation, or joint venture to which the prime Contractor, with the written consent of the Department, subcontracts part of the Contract.

Subgrade. The top earthwork surface of a roadbed, prior to application of Select or Stabilized material courses, shaped to conform to the typical section on which the pavement structure and shoulders are constructed, or surface that must receive an additional material layer, such as Topsoil, Stone or other Select Material.

Subgrade stabilization. The modification of roadbed soils by admixing with stabilizing or chemical agents that will increase the load bearing capacity, firmness, and resistance to weathering or displacement.

Subletting. Subcontracting

Substructure. The part of a structure that is below the bearings of simple and continuous spans, skewbacks of arches, and tops of footings of rigid frames, together with the back walls, wingwalls, and wing protection railings.

Superintendent. The Project representative of the Contractor who is authorized to receive and fulfill instructions from the Engineer and who supervises and directs the construction.

Superstructure. The portion of a structure that is not defined as substructure.

Supplemental specifications. Additions and revisions to the *Road and Bridge Specifications* identified in the Contract Documents

Surety. A corporate entity bound with and for the Contractor for full and complete fulfillment of the Contract and for payment of debts pertaining to the work. When applied to the proposal guaranty, it refers to the corporate body that engages to be responsible in the execution by the bidder, within the specified time, of a satisfactory Contract and the furnishing of an acceptable payment and contract bond.

Surface course. One or more top layers of a pavement structure designed to accommodate the traffic load, which is designed to resist skidding, traffic abrasion, and disintegrating effects of weather. Also see wearing course.

Surplus material. Material that is present on a project as a result of unbalanced earthwork quantities, excessive swell, slides, undercutting, or other conditions beyond the control of the Contractor

Suspension. A written notice issued by the Engineer to the Contractor that orders the work on a project to be stopped wholly or in part as specified. The notice will include the reason for the suspension.

-T-

Temporary structure. Any structure that is required to maintain traffic while permanent structures or parts of structures specified in the Contract are constructed or reconstructed. The temporary structure shall include earth approaches.

Theoretical maximum density. The maximum compaction of materials that can be obtained in accordance with the values established VTM-1.

Tidewater, Virginia. Areas within the Commonwealth as defined in the Department of Conservation and Recreation Erosion and Sediment Control Manual.

Topsoil: The uppermost original layer of material that will support plant life and contains more than 5 percent organic material reasonably free from roots exceeding 1 inch in diameter, brush, stones larger than 3 inches in the largest dimension and toxic contaminants.

Ton. A short ton; 2,000 pounds avoirdupois.

Top of earthwork. The uppermost surface of the regular or embankment excavation, not including select material, that is shaped to conform to the typical section shown in the plans or directed by the Engineer.

Traveled way. The portion of the roadway for the movement of vehicles, not including shoulders.

-U-

Unsuitable Material. Any material which contains more than 5 percent by weight organic matter, or which has unstable bearing capacity, excessive moisture content, plasticity indexes or liquid indexes, or other characteristics defined by the Engineer or the Contract Documents as unsuitable for the use intended.

Utilities. Private, county, city, municipal or public facility, designed, owned and maintained for public use, such as electricity, water, sanitary sewer, storm sewer, drainage culverts, telecommunications, conduits, gas, oil, fiber optics, cable television, that is not identified as a Pavement Structure, Roadway, Highway, Street or Traveled Way.

-V-

Vouchered. The action of approval by the Department; constitutes the date of release to the State Comptroller for payment.

-W-X-Y-Z-

Wearing course. (See **Surface course**) The top and final layer of any pavement

Work. The furnishing of all materials, labor, tools, equipment, and incidentals necessary or convenient for the successful completion of the project and the carrying out of the duties and obligations specified in the Contract.

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 the Contractor is required to submit to the Engineer for review.

Work Order. A written agreement made between the Contractor and the Engineer in order to establish changes to the contract. A work order may be used to add, modify, or delete: pay items, contract time, or other terms of the contract. Work orders may be issued on a bilateral or unilateral basis.

Work Order, Bilateral. A written change order to the Contract where the Engineer and Contractor agree upon scope cost and time estimation for the proposed work. The process uses Form C-10 to perform, communicate and integrate the required and approved change. This type of work order is what is typically meant when the term *work order* is used elsewhere in Department publications.

Work Order, Unilateral. A written directive to the Contractor signed only by the Engineer used to effect a contract change when the Contractor and the Department cannot agree upon the cost and time estimation of the change or where due to issues of emergency, safety, environmental damage, other similar critical factors the Department must act quickly and unilaterally to effect the change. In these cases, the Department must act unilaterally to establish a cost or time adjustment for additional work to the Contract. The process uses Form C-10 to perform, communicate and integrate the required and approved change.

SECTION 102—BIDDING REQUIREMENTS AND CONDITIONS

102.01—Prequalification of Bidders

- (a) All prospective contractors, joint ventures and subcontractors shall prequalify with the Department and shall have received a certification of qualification in accordance with the Rules Governing Prequalification Privileges prior to bidding. These rules and regulations can be found within the Department's Rules Governing Prequalification Privileges. This requirement may be waived by a Contract provision. Prequalification will not be required for items noted in the proposal as "Specialty Items."

The names of persons authorized to sign bids shall be on file with the Department. A name will be considered to be on file if it appears as that of an officer, a partner, or an owner on the current Contractor's Prequalification Application. Requests by the bidder to revise the list of persons authorized to sign bids shall be submitted in writing and approved prior to the date bids are opened. A bid signed by someone whose name is not on file may be rejected.

A bidder who makes a false certification on the Bid will be subject to forfeiture of the bid bond or disqualification from bidding on future work for a 90-day period, or both.

When an individual is prequalified to bid jointly only with a specific company, the joint venture will be considered a unified entity for qualification purposes.

Bidders seeking new prequalification must complete and submit the prequalification package.

Bidders intending to submit bids consistently shall prequalify at least once each two years using the Prequalification Renewal Application. However, the maximum capacity rating or classification, or both, may be changed by the Department during that period if additional favorable reports are submitted or upon unsatisfactory performance as determined in accordance with the requirements of Section 108.03 or from the Contractor's performance evaluations or upon non-performance as determined in accordance with the provisions of Section 108.07. The Department may require a Contractor to furnish a current financial and experience statement at any time.

- (b) If prequalification is approved, prospective bidders will be placed on the Department's List of Prequalified Vendors. Bidders are subject to varying levels of pre-qualification as stated within the Rules Governing Prequalification Privileges. Bidders will be subject to removal from this list based on disqualification in accordance with the Specifications and Prequalification rules and regulations.

Unless otherwise stated, consideration for reinstatement to the Department's List of Prequalified Vendors will be made by the Contract Engineer.

102.02—Content of Proposal

- (a) **Standard Proposal** - Upon request, the Department will furnish a proposal to any interested party. The proposal will specify the location and description of the contemplated construction, the estimate of the various quantities and kinds of work to be performed or materials to be furnished, and a schedule of items for which unit bid prices are invited. The proposal will specify the time in which the work shall be completed and the date and time by which bids must be filed. The proposal will also include any applicable supplemental specifications, special provisions, or special provision copied notes governing the proposed work.

Attachments to the proposal will be considered a part of the bid. The plans, Specifications, and other documents specified in the proposal will be considered a part of the proposal.

- (b) **Combination or Conditional Proposals**—If the Department so elects, proposals may be issued for projects in combination or separately. Bids may be submitted for either the combination or separate units of the combination. The Department may make awards on combination bids or separate bids to its best advantage. Combination bids other than those set up in the proposals by the Department will not be considered. Conditional bids will be considered only when so stated in the proposal.

102.03—Interpretation of Quantities in Proposal

The quantities appearing in the proposal are approximate only, and provide a basis for cost analysis. The Contractor will be paid for the quantities of work accepted and materials furnished and correctly placed or installed in accordance with the requirements of the Contract. The scheduled quantities of work to be performed and materials to be furnished may be increased, diminished, or omitted as provided within these Specifications. When payment of any item in the Contract is indicated to be on the basis of plan quantities, the Contractor will be paid in accordance with the requirements of Section 109.02.

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

Information contained in the bid proposal regarding utility locations is advisory only and shall not be construed as being a representation of completeness or accuracy. The bidder shall contact the owners of the various utilities to determine the exact location of the utilities and the owner's schedule of work. Unless otherwise noted, all utility adjustments will be performed by the Utility or its representative. The Contractor shall cooperate with the owners of any utilities in their adjustment operations. Prior to preparing a bid, the bidder shall contact known utility owners to determine the nature, extent, and location of existing, adjusted, or proposed new utility facilities within the areas of construction. It is understood and agreed that the Contractor has considered in his bid all of the permanent and temporary utility appurtenances in their present and relocated positions, any proposed utility capital improvements, and the Contractor has contacted the utility owner with regard to their proposed schedule of work. The Contractor shall include in his proposed schedule the amount of time to make utility adjustments, from time estimates furnished by the utility owners. Any costs associated with contacting and coordinating with the utilities shall be reflected in the bid price for other items in the Contract.

102.04—Examination of Site of Work and Proposal

(a) Evidence of Examination of Site of Work and Proposal

The submission of a bid will be considered conclusive evidence that the bidder has examined the site of the proposed work, the bid proposal and other documents referenced therein, and the plans before submitting a bid and is satisfied as to the conditions to be encountered in performing the work and the requirements specified in the proposal.

(b) Subsurface Data

Subsurface data may be available for review by the bidder in the office of the District Materials Engineer or State Materials Division Administrator or as stated elsewhere in the proposal documents. Such data are accurate with regard to test holes and are made available to the bidder in good faith in order to apprise him of information in possession of the Department. Any conclusions drawn by the Department concerning subsurface conditions are based solely on the data and are merely indications of what appear to be existing subsurface conditions. The Department does not warrant these conclusions to be correct, either expressly or by implication. Further, the Department does not warrant the condition, amount, or nature of the material that may be encountered or the sufficiency of the data, either expressly or by implication. The bidder shall make his own interpretation of the subsurface data that may be available and satisfy himself with regard to the nature, condition, and extent of the material to be excavated, graded, or driven through. The submission of a bid will be considered conclusive evidence that the bidder is satisfied with regard to the subsurface conditions to be encountered in the work and has taken such conditions into consideration when submitting the bid.

(c) Notice of Alleged Ambiguities

If a word, phrase, clause, or any other portion of the proposal is alleged to be ambiguous, the Bidder shall submit to the State Contract Engineer a written notice of the alleged ambiguity not later than 10 days prior to the date of receipt of bids and request an interpretation

thereof. This written notice shall be submitted via the CABB (Contractor Advertisement Bulletin Board) system located on the Construction website at www.VDOT.Virginia.gov. Authorized interpretations will be issued by the State Contract Engineer to each person who received a proposal and will be posted on the CABB system. These questions, answers and statements from the CABB will be added to the contract as addenda.

The Department will not be responsible for any other explanations or interpretations of the alleged ambiguities except those brought to the attention of and responded to by the State Contract Engineer. No employee or agent of the Department shall have the authority to furnish any explanation or interpretation, verbal or written, of alleged ambiguities that are not submitted to the Contract Engineer by the bidder.

If the bidder fails to give written notice and request an interpretation of the alleged ambiguity within the specified time, he shall waive any right he may have had to his own interpretation of the alleged ambiguity.

102.05—Preparation of Bid

(a) General

The names of persons authorized to sign bids shall be on file with the Department. A name will be considered to be on file if it appears as that of an officer, a partner, or an owner on the current Contractor's Prequalification Application. Requests by the bidder to revise the list of persons authorized to sign bids on their behalf shall be submitted in writing and approved prior to the date bids are opened. A bid signed by someone whose name is not on file as someone authorized by the bidder may be rejected.

If the bid is made by an individual, the name and address of the individual shall be shown; if by a partnership, its name and address and the name and title of the partner signing the bid shall be shown; if by a corporation, the name of the corporation, its address, and the name and title of the officer signing the bid shall be shown; if by a joint venture, the aforementioned information shall be shown for each party.

The bidder shall submit his bid by approved electronic media, unless otherwise provided for in the proposal. Bids shall be signed with a digital signature.

The bidder shall furnish a unit or lump sum price as called for in the bidding proposal, in numerical figures, for each pay item listed. The bidder shall also show the products of the unit prices and quantities in numerical figures in the column provided for that purpose and the total amount of the bid.

If a unit or lump sum price is omitted, the bid will be rejected. If there is a discrepancy between the unit price and its extension, the unit price will govern.

In the event there is a discrepancy between the bidder's electronically generated proposal form and the official proposal form as furnished by the Department, the Department proposal form will govern.

Bids will be considered irregular and may be rejected for *any* of the reasons stated in Section 102.06.

The Bidder shall submit a proposal guaranty in accordance with the requirements of Section 102.07.

A bid may be rejected and the Bidder may be disqualified for *any* of the reasons stated in Section 102.08.

(b) Design Options

Except as otherwise specified in the proposal, when regular and alternate design options are shown in the proposal, the bidder shall submit a bid price for at least one design option. The award of the Contract will be made on the basis of the lowest responsive and responsible bid submitted for either of the options. The Department may award the Contract to the bidder who submitted the lowest bid for the regular design option or the lowest bid for the alternate design option, whichever is deemed to be in the best interest of the Commonwealth.

(c) Debarred Suppliers

The bidder is cautioned against utilizing price quotes for materials for use in the preparation of bids from suppliers or vendors that are debarred by the Department. The Engineer will not approve for use any material furnished by a supplier debarred by the Department. The bidder shall ascertain from the Department's listings which suppliers are debarred. Lists of approved suppliers can be found on the Department's Materials Division web site.

If a previously debarred supplier is reinstated to eligibility subsequent to the award of a contract, the Engineer may approve the use of the supplier when requested by the Contractor.

All bidders shall return Form No. C-48 listing all subcontractors/suppliers that were solicited to supply quotes for work on this project within 10 calendar days after the date designated in the proposal for the opening of bids. This form shall show the vendor numbers, legal names of subcontractors/suppliers, whether DBE or non-DBE, and utilization or non-utilization for work on this project.

(d) Required Certifications

A bidder who makes a false certification on the Bidder Certification of Prequalification Classification and Work Capacity Form will be subject to forfeiture of his bid bond or disqualification from bidding on future work for a 90-day period, or both. The State Contract Engineer will determine the imposition and extent of such sanctions.

A sworn statement shall be executed by the bidder or his agent on behalf of each person, firm, association, or corporation submitting a bid. The statement shall certify that the person, firm, association, or corporation has not, either directly or indirectly, entered into any agreement, participated in any collusion, or otherwise taken any action to restrain free competitive bidding in connection with the proposal. The sworn statement shall be part of the electronic bid or in the form of an affidavit furnished by the Department and shall be sworn to before a person who is authorized by the laws of the Commonwealth to administer oaths. The electronic bids shall contain the identical sworn statement. For the purpose of this Section, affixing a digital ID to the bid will be considered by the Department conditional evidence of signing before a person who is authorized by the laws of the Commonwealth to administer oaths.

(e) Acknowledgement of Receipt of Revisions

The bidder shall acknowledge receipt of all revisions to the bid documents issued prior to receipt of bid by inserting the appropriate Revision Letter date(s) as part of his electronic bid submission. Failure by the bidder to acknowledge any Revision Letter date(s) with his bid may result in the bidder being considered non-responsive, his bid irregular, and the bid being rejected.

(f) Signing the Bid

The bid shall be signed by the individual, one or more members of a partnership, or one or more of the officers of a corporation, whichever is applicable, by a digital identification. For a joint venture, the bid shall be signed by the individual identified prior to receipt of bids, as representing the joint venture. If the individual is not previously identified as representing a joint venture, the firm of record is responsible for the bid.

102.06—Irregular Bids

Bids will be considered irregular and may be rejected for *any* of the following reasons:

- (a) if the bidder fails to comply with the requirements of Sections 102.05 and 102.07
- (b) if the bidder adds any provisions reserving the right to accept or reject an award or enter into a contract pursuant to an award except as otherwise permitted in these Specifications
- (c) If the bidder fails to provide Certification of Prequalification Classification and Work Capacity
- (d) if the bid is not properly signed
- (e) if the bidder fails to acknowledge a Revision Letter.
- (f) if there are unauthorized additions, conditional or alternate bids, or irregularities of any kind that may make the bid incomplete, indefinite, or ambiguous
- (g) if the unit prices in the bid are obviously unbalanced, either in excess or below the cost analysis values as determined by the Department
- (h) if the bidder fails to submit a statement concerning collusion
- (i) if bids are submitted showing a designation for a project other than the project for which the bid is made
- (j) if a paper bid is not totaled
- (k) if erasures or alterations in the bidder's entries on paper bids, when allowed, are not initialed by the bidder
- (l) if any attachments included in the bid are detached or altered when the bid is submitted except as otherwise provided for herein

- (m) failure to be registered with “eVA Internet e-procurement solution” prior to the award of the Contract.

102.07—Proposal Guaranty

A bid in excess of \$250,000.00 will not be accepted or considered unless accompanied by a guaranty in the form of a bid bond made payable to the Treasurer of Virginia. A bid bond will be accepted only if executed on a form that contains the exact wording as the form furnished by the Department. Any bid accompanied by a bond having wording that differs in any respect from that furnished by the Department will be rejected. The amount of the proposal guaranty shall be 5 percent of the total bid.

When the principal is a joint venture, each party thereof shall be named and shall execute the proposal guaranty. Each surety to the bid bond shall be named and shall execute the bid bond. The bid bond shall be accompanied by a certified copy of the power of attorney for the surety’s attorney-in-fact.

102.08—Disqualification of Bidder

Any of the following causes may be considered sufficient for the disqualification of a bidder and rejection of his bid:

- (a) more than one proposal for the same work from an individual, partnership, corporation or joint venture under the same or different name. A proposal submitted by an affiliate of an individual, partnership, corporation or any party of a joint venture will be considered as more than one proposal submitted for the same work. *Affiliate* as used herein shall conform to the definition in Section 101.02 - Terms.
- (b) evidence of collusion among bidders; participants in such collusion will not be considered for future bids until requalified by the Board
- (c) incompetency or inadequate machinery, plants, or other equipment as revealed by the bidder’s financial and experience statements required by these Specifications
- (d) unsatisfactory workmanship or progress as described within Sections 105.05, 108.03, 108.07 or other applicable specifications and demonstrated by performance records of current or past work for the Department, other agencies or departments of the Commonwealth, or agencies or departments of other states in the United States or federal government
- (e) uncompleted work with the Department that in the judgment of the Engineer might hinder or prevent prompt completion of additional work if awarded
- (f) failure to pay or settle satisfactorily all bills for materials, labor, equipment, supplies, or other items specified in contracts in force at the time the new work comes before the Board for award
- (g) failure to comply with any prequalification regulation of the Department
- (h) failure to cooperate properly with representatives of the Commonwealth inspecting, monitoring or administering construction or disorderly conduct toward any such representative in previous contracts

102.08

- (i) default under a previous contract, or
- (j) Failure to pay back amounts owed the Department, as specified in Section 109.10, on other contracts

Temporary disqualification of a bidder as provided herein will result in the temporary disqualification of each member of a joint venture and any affiliate, having substantially the same operational management or drawing from the same equipment or labor resource pool. Temporary disqualification will also result in non-approval of the bidder, each member of a joint venture, and affiliates as defined herein, for performance of work as subcontractors that in the opinion of the State Contract Engineer, could adversely affect other work under contract to the Department.

The above listed reasons for possible disqualification are not totally inclusive and disqualification may occur based on other requirements within these Specifications.

Bidders who are disqualified may be reinstated, at the discretion of the State Contract Engineer or the Prequalification Panel, upon satisfactory compliance with the requirements of these Specifications.

102.09—Submission of Bid

Each bid shall be submitted to the Department by approved electronic media in accordance with the policy in place at the time of the advertisement and bid. This information will be posted on the Construction website at www.virginiadot.org/business/const. Refer to “Electronic Bidding” information.

Bids shall be filed prior to the time and at the place specified in the Notice of Advertisement. Bids received after that time will be returned to the bidder unopened. The date for the opening of bids may be deferred by the Department, in which case the bidders will be notified.

102.10—Withdrawal of Bid

A bidder may withdraw a bid in accordance with the following.

- (a) **Standard Withdrawal:** Bids may be withdrawn as allowed by the electronic bidding system until bid closing. A bidder may withdraw a bid provided the request for the withdrawal is written and signed by a person(s) who qualifies to execute the bid in accordance with the requirements of Section 102.05.
- (b) **Conditional Withdrawal:** A bidder who desires to bid on more than one project for which bids are to be opened on the same date and desires to protect himself against receiving awards for more projects than he is equipped to handle may secure the protection desired by completing the portion of the electronic bid for the conditional withdrawal of bids.

102.11—eVA Business-To-Government Vendor Registration

Bidders are not required to be registered with “eVA Internet e-procurement solution” at the time bids are submitted, however, prior to award, the lowest responsive and responsible bidder must be registered with “eVA Internet e-procurement solution” or the bid will be rejected. Registration shall be

performed by accessing the eVA website portal www.eva.state.va.us, following the instructions and complying with the requirements therein.

102.12—Public Opening of Bids

Electronic bids will be decrypted, opened, printed to paper and along with all other bids will be read publicly at the time and place specified in the Notice of Advertisement. Interested parties are invited to be present. As-Read results will be posted on the Construction website at www.VDOT.Virginia.gov as soon as possible on the day of reading.

SECTION 103—AWARD AND EXECUTION OF CONTRACTS

103.01—Consideration of Bids

After bids have been opened and read, the Department will evaluate bid submittals to determine if all requirements of Section 102 have been met. Bids not submitted in accordance with the requirements of Section 102 will be rejected.

Bids will be compared on the basis of the summation of the products of the quantities shown in the bid schedule and the unit bid prices.

The Department may correct arithmetical errors in the bid prior to such comparison, in accordance with Section 102.05. The results of the comparisons will be available to the public after the determination has been made to award the Contract.

The Board reserves the right to reject any or all bids, waive technicalities, advertise for new bids, or proceed to do the work otherwise if it deems that the best interest of the Commonwealth would be promoted thereby.

103.02—Award of Contract

If the Contract is awarded, the award will be made to the lowest responsive and responsible bidder without discrimination on the grounds of race, color, sex, or national origin. In the event of tie bids, preference will be given to Virginia persons, firms, or corporations; otherwise, the tie will be decided by lot. Whenever any bidder is a resident of any other state and such state under its laws allows a resident contractor of that state a preference, a like preference may be allowed to the lowest responsive and responsible bidder who is a resident of Virginia. The award date will not be later than midnight on the 60th day after the opening of bids. If the Board, or the Commissioner; where permitted by law, has not awarded the Contract within this period, the bidder may withdraw his bid without penalty or prejudice unless the time limit is extended by mutual consent.

103.03—Cancellation of Award

The Board, or the Commissioner; where permitted by law, may cancel the award of any contract at any time before the execution of the contract by all parties without liability to the Commonwealth.

103.04—Forfeiture of Proposal Guaranty

When the bidder withdraws his bid prior to award, after being determined the apparent low bidder, the bid bond will be forfeited in accordance with the requirements of the *Code of Virginia* as amended.

103.05—Requirements of Contract Bond

Within 15 calendar days after notification of award of the Contract the successful bidder shall furnish the following bonds for contracts in excess of \$250,000.00:

- (a) a performance bond in the sum of the Contract amount, conditioned upon the faithful performance of the Contract in strict conformity with the plans, Specifications and conditions of the Contract, and
- (b) a payment bond in the sum of the Contract amount, conditioned upon the prompt payment for all labor, materials, public utility services and rental of equipment used in the prosecution of the work for the Contract.

Bidders will not be awarded an unbonded contract when their bid plus the balance of other unbonded contracts exceeds \$250,000.00 or as otherwise limited by their current prequalification status.

The bonds shall be made on official forms furnished by the Department and shall be executed by the bidder and a surety company carrying a minimum “Best Rating” of “B +” and authorized to do business in Virginia in accordance with the laws of Virginia and the rules and regulations of the State Corporation Commission. To be considered properly executed, the bonds shall include authorized signatures and titles.

103.06—Contract Documents

The portion of the executed Contract submitted by the Contractor shall include the following documents unless the filing of any of them at a later date is specifically permitted by other sections of these Specifications or by Special Provisions or Special Provision Copied Notes:

- (a) **Contract:** The Contract shall include the schedule of prices submitted by the bidder, plans, standard drawings, these Specifications, supplemental specifications, special provisions, special provision copied notes, and the standard form of the Contract, all as furnished by the Department.
- (b) **Contract Bonds:** Contract bonds shall conform to the requirements of Section 103.05.
- (c) **Affidavits and Documents:** Affidavits and documents shall include those required to be made a part of the Contract by any federal or state law in effect on the date of the Notice of Advertisement.
- (d) **Workers’ Compensation Insurance Certificate:** The certificate shall be filed on forms furnished by the Department within 15 calendar days after notification of award of the Contract. The certificate shall be executed by an approved and authorized insurance company as required by state law and shall cover the Contract it accompanies.

The Contractor shall file notice with the Department at least 30 days prior to the cancellation of any required workers' compensation coverage. If any of his insurance of this class is cancelled, the Contractor shall cease operations on the date of the cancellation and shall not resume operations until new insurance is certified as being in force.

- (e) **Progress Schedule:** The Contractor shall submit a progress schedule in accordance with the requirements of Section 108.03 or as specified in the Contract Documents.
- (f) **Contractor's Bodily Injury and Property Damage Liability Insurance:** The Contractor shall procure and maintain at his own expense, until final acceptance of the work covered by the Contract, insurance of the kinds and in the amounts specified herein. The minimum limits of liability for this insurance shall be as follows:

A Combined Single Limit for Bodily Injury Liability and Property Damage Liability	
\$1,000,000	Each Occurrence
\$2,000,000	Aggregate

Evidence of insurance in compliance with the above shall be filed on forms approved by the Department within the time specified herein. The evidence shall be executed by an approved and authorized insurance company authorized to do business in Virginia and with a minimum "Best Rating" of "B +", and shall cover the Contract it accompanies.

The Contractor shall file notice with the Department at least 30 days prior to the cancellation or reduction of the required insurance, and shall cease operations on the date of the cancellation or reduction until new insurance is in force and the same evidence of insurance is provided to the Department.

The Contractor's Bodily Injury and Property Damage Liability Insurance shall cover liability of the Contractor for damage because of bodily injury to, or death of persons and damage to, or destruction of property, that may be suffered by persons other than the Contractor's own employees as a result of the negligence of the Contractor in performing the work covered by the Contract.

Insurance provided in compliance with this Section shall include liability of the Contractor for damage to or destruction of property that may be suffered by persons other than the Contractor's own employees as a result of blasting operations of the Contractor in performing the work covered by the Contract.

If any part of the work is sublet, insurance meeting the same requirements shall be provided by or in behalf of the subcontractors and evidence of such insurance shall be submitted with the sublet request.

Insurance coverage in the minimum amounts set forth herein shall not be construed to relieve the Contractor or subcontractor(s) of liability in excess of such coverage, nor shall it preclude the Commonwealth from taking such actions as are available to it under any other provision of this Contract or otherwise in law.

103.07—Failure to Furnish Bonds or Certificate of Insurance

Failure by the successful bidder to furnish the Department acceptable bonds, workers' compensation insurance or the Contractor's Bodily Injury and Property Damage Liability Insurance policy within 15 calendar days after being notified of the award of the Contract shall be considered just cause for cancellation of award and forfeiture of the proposal guaranty. In such event, the proposal guaranty shall become the property of the Commonwealth, not as a penalty but in liquidation of damages sustained. The Contract may then be awarded to the next lowest responsible bidder, or the work may be re-advertised or constructed otherwise, as determined by the Board.

In the event the successful bidder on an unbonded contract is unwilling or unable to fulfill the Contract and fails to notify the Department prior to execution of the Contract by the Department, the bidder will be declared in default in accordance with the requirements of Section 108.07.

In the event the bidder, on an unbonded contract, notifies the Department prior to execution of the Contract by the Department of such unwillingness or inability to fulfill the Contract, the bidder will be enjoined from bidding on an unbonded contracts for a period of no less than 90 days from the date of notice by the Department.

A bidder who has never been enjoined or defaulted on an unbonded contract and who notifies the Department prior to contract execution of an unwillingness or inability to fulfill the Contract will not be enjoined for the first occurrence; however, said bidder will not be permitted to rebid or perform work on that specific Contract.

103.08—Contract Audit

The Contractor shall permit the Department to audit, examine, and copy all documents, computerized records, electronic mail, or other records of the Contractor during the life of the Contract and for a period of not less than five years after the date of final payment, or the date the Contractor is declared in default of Contract, or the date of termination of the Contract. The documents and records shall include, but not be limited to:

- (a) Those that were used to prepare and compute the bid, prepare all schedules used on the project, record the progress of work on the project, accounting records, purchasing records, personnel payments or records necessary to determine employee credentials, vendor payments and written policies and procedures used to record, compute and analyze all costs incurred on the project, including those used in the preparation or presentation of claims to the Department.
- (b) Records pertaining to the project as the Department may deem necessary in order to permit adequate evaluation and verification of Contractor's compliance with contract requirements, compliance with the Department's business policies, and compliance with provisions for pricing work orders or claims submitted by the Contractor or the Contractor's subcontractors, insurance agents, surety bond agents and material suppliers shall be made available to the auditor(s) at the Department's request. The Contractor shall make his personnel available for interviews when requested by the Department.
- (c) Upon request, the Contractor shall provide the Department with data files on data disks, or other suitable alternative computer data exchange format. Data furnished by the Contractor that cannot be verified will be subject to a complete audit by the Department.

The Contractor shall ensure that the requirements of this provision are made applicable to his subcontractors, insurance agents, surety bond agents and material suppliers. The Contractor shall cooperate and shall cause all related parties to furnish or make available in an expeditious manner all such information, materials, and data. The Contractor shall be forthcoming in disclosing all sources and locations of media.

The Contractor shall provide immediate access to records for the audit and provide immediate acceptable facilities for the audit. Failure on the part of the Contractor to afford the Department immediate access or proper facilities for the audit will be considered failure to cooperate and will result in disqualification as a bidder in accordance with Section 102.08.

Upon completion of the contract audit, any adjustments or payments due by the Contractor as a result of the audit shall be made within 60 days from presentation of the Department's findings to the Contractor. Failure on the part of the Contractor to make payment may result in disqualification as a bidder in accordance with Section 102.08.

If the Contractor disagrees with the findings of the Department's audit, the Contractor may appeal the decision in accordance with provisions of Section 105.19 or the *Code of Virginia* as amended and as applicable, except that the provision for the Contractor to submit a claim within 60 days after final payment shall not apply. If the Contractor elects to appeal the decision of the audit he shall within 60 days of the date of the notice of the Department's findings submit a written request to appeal the decision to the Chief Engineer. Failure on the part of the Contractor to file a claim disputing the Department's audit within 60 days will be interpreted as a waiver of any claim for dispute of the Department's findings.

103.09—Execution of Contract

The bid as submitted, including the documents specified in Section 103.06(a) shall constitute the Contract upon submittal of the contract bond, contract bodily injury and property damage liability insurance certificate, and workers' compensation insurance certificate and the final execution by the Department. After the Department has recommended the bid for award the apparent low bidder shall be required to sign and return a paper copy of the contract documents to the State Contract Engineer. Failure to sign and return the contract documents will result in forfeiture of the bid bond. If the Contract is not awarded within the time limit specified in Section 103.02, the bidder may withdraw his bid without penalty or prejudice unless the time limit is extended by mutual consent. No Contract shall be considered effective until it has been fully executed by all parties.

SECTION 104—SCOPE OF WORK

104.01—Intent of Contract

The intent of the Contract is to provide for completion of the work specified therein within the budget and time limit stated in the Contract. Further it is understood that the Contractor execute the work under the contract as an independent contractor and not as an agent of the Department, the Commissioner or the Commonwealth Transportation Board.

104.02—Alteration of Quantities or Character of Work**(a) General**

The Engineer reserves the right to make, in writing, at any time during the work, such changes in quantities and such alterations in the work as are necessary to complete the project satisfactorily. Such changes in quantities and alterations shall not invalidate the Contract or release the surety, and the Contractor shall agree to perform the work as altered. No change, alteration or modification in or deviations from the Contract or the Contract Documents, or the giving by the Department of any extension of time for the performance of the Contract, or the forbearance on the part of the Department shall release or exonerate in whole or in part either the Contractor or any surety on the obligations of any bond given in connection with the Contract. Neither the Department nor the Contractor shall be under any obligation to notify the surety or sureties of any such alteration, change, extension or forbearance, notice thereof being expressly waived. Any increase in the Contract amount shall automatically result in a corresponding increase in the penal amount of the bonds without notice to or consent from the surety, such notice and consent being hereby waived. Decreases in the Contract amount shall not, however, reduce the penal amount of the bonds unless specifically provided in any change order as authorized in accordance with the provisions of Section 109.05 decreasing the scope of the work.

If the alterations in the nature of the work or changes in quantities, significantly change the character of the work under the Contract, an adjustment, excluding anticipated profits for reduced or eliminated work, may be made to the Contract. The basis for the adjustment shall be agreed upon prior to the performance of the work. If a basis cannot be agreed upon, an adjustment will be made either for or against the Contractor in such amount as the Engineer may determine to be fair and equitable.

At the option of the Engineer, the Contractor may be directed to accomplish the work on a force account basis when the scope of work meets the requirements for such a determination in accordance with the requirements of Section 109.05.

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

The term *significant change* shall be construed to 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 of work, as defined elsewhere in the contract is increased or decreased more than 25 percent of the original contract quantity. Any allowance for an increase or decrease in cost due to an increase in quantity of more than 25 percent shall be calculated only on that quantity in excess of 125 percent of the original contract bid item quantity. Also any allowance for an increase or decrease in cost due to a decrease in quantity of more than 25 percent shall be calculated only on that quantity below 75 percent of the original contract bid item quantity, or in case of a decrease below 75 percent, to the actual amount of work performed, or

- (3) When overruns and underruns of piling amount to more than 25 percent of the original bid quantity, whether or not such item has been designated as a major item, or
- (4) When overruns or underruns of more than 100% on minor items can be demonstrated as not representative of the true cost of the work when considering the unit bid price.

(b) Value Engineering Proposals

The Contractor may submit to the Engineer written Value Engineering Proposals (VEP) for modifying the plans, Specifications, or other requirements of the Contract for the purpose of reducing the total cost and/or contract time of construction without reducing the design capacity or quality of the finished product. If the VEP is accepted by the Department, the net savings and/or contract time will be equally divided by the Department and the Contractor. When an accepted VEP includes contract time savings, the contract completion date shall be advanced by half of the time savings accepted in the VEP and the Contractor shall have exclusive use of the remaining half of the time as contractor float.

Each VEP shall result in a net savings over the contract cost and/or contract time without impairing essential functions and characteristics of the item(s) or of any other part of the project, including, but not limited to, service life, reliability, economy of operation, ease of maintenance, aesthetics, and safety. At least the following information shall be submitted with each VEP:

- Statement that the proposal is submitted as a VEP
- Statement concerning the basis for the VEP, benefits to the Department and an itemization of the contract items and requirements affected by the VEP
- Detailed estimate of the cost and/or contract time under the existing Contract and under the VEP
- Proposed specifications and recommendations as to the manner in which the VEP changes are to be accomplished
- Statement as to the time by which a contract work order adopting the VEP must be issued so as to obtain the maximum cost-effectiveness

The Department will process the VEP in the same manner as prescribed for any other proposal that would necessitate issuance of a work order. The Department may accept a VEP in whole or part by issuing a work order that will identify the VEP on which it is based. The Department will not be liable to the Contractor for failure to accept or act on any VEP submitted pursuant to these requirements or for delays in the work attributable to any VEP. Until a VEP is put into effect by a work order, the Contractor shall remain obligated to the terms and conditions of the existing Contract. If an executed work order has not been issued by the date on which the Contractor's proposal specifies that a decision should be made or such other date as the Contractor may subsequently have specified in writing, the VEP shall be deemed rejected.

The work order effecting the necessary modification of the Contract will establish the net savings agreed on, provide for adjustment of the contract prices, and/or contract time, and indicate the net savings. The Contractor shall absorb all costs incurred in preparing a VEP. Costs for reviewing and administering a VEP will be borne by the Department. The Department may include in the agreement any conditions it deems appropriate for consideration, approval, and implementation of the VEP. The Contractor's 50 percent share of the net savings and/or contract time shall constitute full compensation to him for effecting all changes pursuant to the agreement.

Unless specifically provided for in the work order authorizing the VEP, acceptance of the VEP and performance of the work thereunder will not change the contract time limit.

The Department may adopt a VEP for general use in contracts administered by the Department if it determines that the VEP is suitable for application to other contracts. VEPs identical with or similar to previously submitted VEPs will be eligible for consideration and compensation under these provisions if they have not been previously adopted for general application to other contracts administered by the Department. When a VEP is adopted for general use, compensation pursuant to these requirements will be applied only to those awarded contracts for which the VEP was submitted prior to the date of adoption of the VEP.

Proposed changes in the basic design of a bridge or pavement type or those changes that require different right-of-way limits will not normally be considered an acceptable VEP. If a VEP is based on or is similar to a change in the plans, Specifications, or special provisions adopted by the Department prior to submission of the VEP, the Engineer will not accept the VEP.

The Engineer will be the sole judge of the acceptability of a VEP. The requirements herein apply to each VEP initiated, developed, and identified as such by the Contractor at the time of its submission to the Engineer. However, nothing herein shall be construed as requiring the Engineer to approve a VEP.

Subject to the provisions herein, the Department or any other public agency shall have the right to use all or part of an accepted VEP without obligation or compensation of any kind to the Contractor.

If a VEP is accepted by the Department, the provisions of (a) herein that pertain to the adjustment of contract unit prices attributable to alterations of contract quantities will not apply to the items adjusted or deleted as a result of putting the VEP into effect by a work order.

104.03—Differing Site Conditions

During the progress of the work, if subsurface or latent physical conditions differing materially from those indicated in the contract are encountered at the site, the Contractor shall promptly notify the Engineer in writing of the specific differing conditions.

If unknown physical conditions of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the work provided for in the Contract, are encountered at the site the Contractor shall promptly notify the Engineer in writing of the specific differing conditions.

Upon receipt of such written notification, the Engineer will acknowledge receipt and investigate the conditions. If it is determined by the Engineer 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, an adjustment, excluding anticipated profits, will be made and the Contract may be modified in writing accordingly. The Engineer will notify the Contractor of the determination whether or not an adjustment of the Contract is warranted.

SECTION 105—CONTROL OF WORK

105.01—Notice to Proceed

Unless otherwise indicated in the Contract, the date of the Notice to Proceed will be the date of contract execution. The State Contract Engineer will contact the Contractor on the date of contract execution to inform him of such action. The State Contract Engineer will confirm this date in the Letter of Contract Execution. This Letter of Contract Execution will be distributed to Department personnel involved in the administration of the Contract and to the Contractor. The Contractor shall begin work within 15 days of the date of contract execution unless the Notice to Proceed date is otherwise indicated in the Contract, in which case the Contractor shall begin work within 15 days of the date of the Notice to Proceed indicated in the Contract.

Contract Time will commence on the date of the Notice to Proceed. The Letter of Contract Execution will identify the Chief Engineer's authorized representative, who is responsible for written directives and changes to the Contract. The Engineer will contact the Contractor after notice of award to arrange a pre-construction conference.

In the event the Contractor, for matters of his convenience, wishes to begin work later than 15 days from the date of Notice to Proceed he shall make such a request in writing to the Engineer promptly after the execution of the Contract. If the Contractor's requested start date is acceptable to the Department, the Contractor will be notified in writing; however, the Contract fixed completion date will not be adjusted but will remain binding. The Contractor's request to adjust the start date for the work on the Contract will not be considered as a basis for claim that the time resulting from Contractor's requested start date, if accepted by the Engineer, is insufficient to accomplish the work nor shall it relieve the Contractor of his responsibility to perform the work in accordance with the scope of work and requirements of the Contract. In no case shall work begin before the Department executes the Contract. The Contractor shall notify the Engineer at least 24 hours prior to the date on which he plans to begin the work.

105.02—Pre-Construction Conference

Within 14 days after notification of award the Contractor shall attend a pre-construction conference scheduled by the Engineer to discuss the Contractor's planned operations for prosecuting and completing the work within the time limit of the Contract. At the pre-construction conference the Engineer and the Contractor will identify in writing the authorities and responsibilities of project personnel for each party. The pre-construction conference may be held simultaneously with the scheduling conference when the Engineer so indicates this in advance to the Contractor. When these are simultaneously held, the Contractor shall come prepared to discuss preparation and submittal details of the progress schedule in accordance with the requirements of the Contract.

The Engineer will be responsible for setting the conference agenda, conducting discussions and ensuring that minutes of the conference are taken and later timely distributed to all attendees. The pre-construction conference will be the venue to review the contract plans and documents. To that end, the conference agenda may include but not be limited to discussions on the general sequence of work, including the expected primary work tasks as defined by the Contractor, and proposed means and methods for the entire scope of work, potential problems or impacts, constructability issues, special considerations such as limitations and access issues, agreements with local agencies or governments, utility impacts or relocations including railroads, coordination with schedules of the utilities and subcontractors and associated work, sources and delivery of critical materials, submittals required by Contract documents including shop drawings, location of field office, labs, etc., environmental concerns including permits and erosion and siltation efforts, maintenance of traffic issues and EEO/DBE/MBE requirements.

The Contractor shall provide the Engineer with a list of all equipment available for use in the prosecution of the work on the contract at the pre-construction conference or no later than one week prior to the first monthly progress estimate. The make, model, size, capacity, and year of manufacture shall be listed for each piece of equipment. Where possible the Contractor shall provide this list in an electronic format. This list may take the form of the Contractor's fleet list of equipment. The Contractor shall provide the Engineer an updated list of equipment as changes occur.

105.03—Authorities of Project Personnel

(a) Authority of Engineer

During prosecution of the work, the Engineer will answer all questions that may arise as to the quantity, quality, and acceptability of materials furnished and work performed; rate of progress of the work; interpretation of the plans and Specifications; acceptable fulfillment of the Contract by the Contractor; disputes and mutual rights between contractors; and compensation.

The Engineer has the authority to suspend the work wholly or in part if the Contractor has created conditions that are unsafe or fails to correct conditions that are unsafe for workers or the general public or fails to carry out the provisions of the Contract. The Engineer may also suspend work for such periods as he may deem necessary because of catastrophic or extraordinary weather in accordance with the definition of such in Section 108.04, conditions considered unsuitable for prosecution of the work, or any other condition or reason deemed to be in the public interest.

The Engineer may issue written clarifications or directives that either enhance or alter the Contract Documents. The Engineer may order such work as may be necessary to complete the Contract satisfactorily.

(b) Authority of Inspector.

Inspectors employed by the Department are authorized to inspect all work performed and materials furnished. Inspection may extend to all or any part of the work and to the preparation, fabrication, and manufacture of the materials to be used. The Inspector is not authorized to alter or waive the provisions of these Specifications or make changes in the plans.

The Inspector is not authorized to make final acceptance of the project, approve any operation or item, or act as foreman for the Contractor. However, the Inspector will have the authority to reject defective work and material and suspend work that is being improperly performed, subject to the concurrence of the Engineer. Such inspection shall not relieve the Contractor of any obligation to furnish acceptable materials or provide completed construction that is in accordance with the requirements of the Contract.

The Inspector will exercise only such additional authority as may be delegated by the Engineer. The Engineer will advise the Contractor in writing of delegations of authority that will affect his operations.

105.04—Gratuities

Gifts, gratuities, or favors shall not be given or offered by the Contractor to personnel of the Department. A gift, gratuity, or favor of any nature whatsoever or offer of such by the Contractor to personnel of the Department shall be a violation of this provision.

The Contractor shall not employ any personnel of the Department for any services without the prior written consent of the Engineer.

If the Engineer determines after investigation that the Contractor or the Contractor's employees, representatives, or agents of any person acting in his behalf have violated this provision, the Contractor may, at the discretion of the Chief Engineer, be disqualified from bidding on future contracts with the Department for a period of six months from the date of the Chief Engineer's determination of such a violation. Any implicated employees, agents, or representatives of the Contractor may be prohibited from working on any contract awarded by the Department for the period of disqualification.

105.05—Character of Workers, Work Methods, and Equipment

(a) Workers

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

Any person employed by the Contractor or any subcontractor who, in the opinion of the Engineer, does not perform his work in a proper and skillful manner or is intemperate or disorderly shall, when directed in writing by the Engineer, be removed by the Contractor or subcontractor employing the person and shall not be employed again on any portion of the work without the written approval of the Engineer. If the Contractor fails to remove the person or furnish suitable and sufficient personnel for proper prosecution of the work, the Engineer may withhold all monies that are or may become due the Contractor and may suspend the work until the Contractor has complied with the Engineer's directive.

(b) Equipment

Equipment shall be of sufficient size and in such mechanical condition as to comply with the requirements of the work and produce a satisfactory quality of work. Equipment shall be such that no damage to the roadway, adjacent property, other highways or danger to the

public will result from its use. The Engineer may order the removal and require replacement of unsatisfactory equipment.

(c) **Work Methods**

When methods and equipment to be used by the Contractor are not prescribed in the Contract, the Contractor is free to use whatever methods or equipment he feels will accomplish the contract work in conformity with the requirements of the Contract.

When the Contract specifies that construction be performed by the use of particular methods and equipment, they shall be used unless others are authorized by the Engineer. If the Contractor desires to use a different method or type of equipment, he may request permission from the Engineer to do so. The request shall be in writing and shall include a full description of the methods and equipment he proposes to use and an explanation of the reasons for desiring to make the change. If permission is not given, the Contractor shall use the specified methods and equipment. If permission is given, it will be on the condition that the Contractor shall be fully responsible for producing construction work in conformity with contract requirements. If, after trial use of the substituted methods or equipment, the Engineer determines that the work produced does not conform to the requirements of the Contract, the Contractor shall discontinue the use of the substitute method or equipment and shall complete the remaining construction with the specified methods and equipment. The Contractor shall remove any deficient work and replace it with work of the specified quality or take such other corrective action as the Engineer may direct. No change will be made in the basis of payment for the construction items involved or the contract time limit as the result of authorizing or denying a change in methods or equipment under these provisions.

105.06—Subcontracting

No portion of the Contract shall be subcontracted or otherwise disposed of without the written consent of the District Administrator or his designee.

The Contractor shall perform with his own organization work amounting to not less than 30 percent of the original contract value unless otherwise noted in the Contract.

The Contractor shall not subcontract any part of the contract work to a contractor who is not prequalified with the Department in accordance with the requirements of Section 102.01, unless otherwise indicated in the Contract. This restriction does not apply to contract specialty items, consultants, manufacturers, suppliers, or haulers. Consent to subcontract or otherwise dispose of any portion of the contract work shall not relieve the Contractor of any responsibility for the fulfillment of the entire Contract.

105.07—Cooperation of Contractor

The Contractor shall give the work the constant attention necessary to facilitate quality and progress and shall fully cooperate with the Engineer, Inspector, and other contractors involved in the prosecution of the work. If any portion of a project is located within the limits of a municipality, military installation, or other federally owned property; the Contractor shall cooperate with the appropriate officials and agents in the prosecution of the work to the same extent as with the Department.

The Contractor shall have on the project at all times during prosecution of work a competent Superintendent capable of reading and understanding the plans and Specifications and experienced in the type of work being performed who shall receive instructions from the Engineer or his authorized representatives. The Superintendent shall have full authority to execute the orders and directions of the Engineer without delay and supply promptly such materials, equipment, tools, labor, and incidentals as may be required.

105.08—Cooperation with Regard to Utilities

The adjustment of utilities consists of the relocation, removal, replacement, rearrangement, reconstruction, improvement, disconnection, connection, shifting, or altering of an existing utility facility in any manner.

Existing utilities within the Department's knowledge at the design stage of the project will be indicated on the plans. Where possible, arrangements for adjusting these utilities will be made by the Department prior to project construction. Existing private and public utilities that require adjustment will be adjusted by the utility owner or if denoted in the Contract, shall be adjusted by the Contractor as a contract item. The new location of such utilities will not normally be shown on the plans. Some utilities may remain or be adjusted within the construction limits simultaneously with project construction operations.

The Contractor shall coordinate project construction with planned utility adjustments and take all necessary precautions to prevent disturbance of the utility facilities. The Contractor shall report to the Engineer any failure on the part of the utility owner to cooperate or proceed with the planned utility adjustments.

The Contractor shall perform contract utility work in a manner that will cause the least inconvenience to the utility owner and those being served by the utility owner.

Existing, adjusted, or new utility facilities that are to remain within the right of way shall be properly protected by the Contractor to prevent disturbance or damage resulting from construction operations. If during prosecution of the work the Contractor encounters an existing utility that requires adjustment he shall not interfere with the utility but shall take the proper precautions to protect the facility and shall promptly notify the Engineer of the need for adjustment.

If the Contractor desires the temporary or permanent adjustment of utilities for his own benefit, he shall conduct all negotiations with the utility owners and pay all costs in connection with the adjustment.

When delays, inconvenience, or damage sustained by the Contractor are deemed by him to be attributable to interference by utility appurtenances, or the operation of moving the same, written requests from the Contractor for an extension of time will be considered provided there has been a delay to either the critical path or the controlling item of work. Such delays shall be demonstrated by an impact analysis of the Contractor's schedule.

If it is determined that interference by utility appurtenances caused a delay of such magnitude or otherwise altered project operations so as to increase significantly the Contractor's cost of performing the work, the Engineer will consider additional compensation limited to the actual costs incurred by the Contractor. Actual costs will not include unabsorbed office overhead unless the delay or impact adversely affects the critical path or controlling item of work to such extent that the fixed completion

date is delayed. Prior to the Engineer's review, the Contractor shall present sufficient documentation to substantiate fully the request for additional compensation. Such documentation shall be furnished in sufficient detail as requested by the Engineer. Nothing herein shall be construed as requiring the payment of additional compensation.

105.09—Cooperation among Contractors

The Department may at any time contract or approve concurrent contracts for performance of other work on, near, or within the same geographical area of the work specified in an existing contract. Contractors shall not impede or limit access to such work by others.

When separate contracts are awarded within the limits of one project, contractors shall not hinder the work being performed by other contractors. Contractors working on the same project shall cooperate with each other. In case of dispute, the Engineer will be the referee, and his decision will be binding on all parties.

When contracts are awarded to separate contractors for known concurrent construction in a common area, the contractors, in conference with the Engineer, shall establish a written joint schedule of operations. The schedule shall be based on the limitations of the individual contracts and the joining of the work of one contract with the others. The schedule shall set forth the approximate dates and sequences for the several items of work to be performed and shall ensure completion within the contract time limit. The schedule shall be submitted to the Engineer for review and approval no later than 30 days after the award date of the later contract and prior to the first monthly progress estimate. The schedule shall be agreeable to, signed by, and binding on each contractor. The Engineer may allow modifications of the schedule when benefit to the contractors and the Department will result.

Any modification of the schedule shall be in writing, mutually agreed to and signed by the contractors, and shall be binding on the contractors in the same manner as the original agreement.

If the contractors fail to agree on a joint schedule of operations, they shall submit their individual schedules to the Engineer, who will prepare a schedule that will be binding on each contractor.

The joint schedule and any modification thereof shall become a part of each contract involved. The failure of any contractor to abide by the terms of the joint schedule will be justification for declaring the contractor in default of his Contract.

Each contractor shall assume all liability, financial or otherwise, in connection with his Contract and shall protect and save harmless the Commonwealth from any and all damages and claims that may arise because of any inconvenience, delay, or loss he experiences as a result of the presence and operations of other contractors working in or near the work covered by his Contract. He shall also assume all responsibility for any of his work not completed because of the presence or operation of other contractors.

Except for an extension of the contract time limit, the Department will not be responsible for any inconvenience, delay, or loss experienced by the Contractor as a result of his failure to gain access to the work at the time contemplated. When the failure to gain access is not due to any fault or negligence of the Contractor, an extension of the contract time limit will be allowed on the basis of the amount of time delayed.

The Department will not assume any responsibility for acts, failures, or omissions of one contractor that delay the work of another except as provided herein.

105.10—Plans and Working Drawings

(a) **General**

The Contractor will be supplied with two copies of the executed Contract. The Department’s *Road and Bridge Specifications* and the Department’s *Road and Bridge Standards* will be available for purchase by the Contractor from the office of the State Contract Engineer.

(b) **Plans**

Plans will be furnished to the Contractor without charge as follows:

Original Contract Amount in Dollars		Number of Plan Sets	
From	To	Full Size	Half Size
0	1,999,999	4	6
2,000,000	4,999,999	6	8
5,000,000	9,999,999	8	10
10,000,000+		10	10

Plan revisions issued while the project is under construction will be furnished to the Contractor in the same sizes and number

The Contractor shall keep one complete set of plans, standard drawings, contract assemblies, and Specifications available on the project at all times. For maintenance projects, certain sign projects, and other projects having no field office or on which the Contractor has no office, the Contractor shall keep one complete set of plans, contract assemblies, and Specifications with him while prosecuting the work. In the event items of work are required as per the Standard Drawings, the Contractor shall also keep the appropriate Standard Drawings on the project during the performance of that work.

Plans consisting of general drawings and showing such details as are necessary to give a comprehensive understanding of the work specified will be furnished by the Department. Except as otherwise shown on the plans, dimensions shown on the plans are measured in the respective horizontal or vertical planes. Dimensions that are affected by gradients or vertical curvatures shall be adjusted as necessary by the Contractor to accommodate actual field conditions and shall be specifically denoted as “field adjusted” on the working drawings. Failure on the part of the Contractor to so denote field adjustments on the working drawings shall not relieve the Contractor of the responsibility to accommodate and incorporate such existing conditions into the finished work.

(c) **Working Drawings**

The Contractor shall furnish working drawings to the extent, detail and number as may be required by the Contract requirements. The Contractor shall submit to the Department for review nine sets of required working drawings unless otherwise indicated in the Contract re-

quirements. Working drawings and submittals shall be identified by the complete state project and job designation number, as well as the federal project number if applicable. Items or component materials shall be identified by the specific contract item number and Specification reference in the Contract. Any changes from the requirements of the Contract shall be specifically denoted, together with justification, and submitted to the Engineer for review. Working drawings shall be submitted in sufficient time to allow for review, discussion and correction prior to the beginning of the work they reference. Work shall not be performed or materials ordered prior to the completion of the Department's review of the working drawings.

Reviewed working drawings will be returned to the Contractor within 30 days from the date of receipt by the Department. If a railroad, municipality, or other entity as specified in the Contract or on the plans is required to review the working drawings, the reviewed working drawings will be returned within 45 days from the date of receipt by the Department. If the working drawings are not returned by the time specified, no additional compensation will be allowed except that an extension of time in accordance with the requirements of Section 108.04 will be considered if the work element detailed by the working drawings is on the project critical path or involves a controlling item of work. Three sets of working drawings marked with any suggested modifications or comments will be returned to the Contractor. The other sets will be retained by the Department.

The Department's review of the Contractor's working drawings will relate to conformance to the requirements of the Contract. The review will not relieve the Contractor from responsibility for errors in the working drawings or from complying with the requirements of the Contract for a fully functional finished work item as specified or designed.

Deviations from the Contract requirements initiated by the Contractor shall be requested in writing and clearly identified on the working drawings. Explicit supporting justification shall be furnished specifically describing the reason for the requested deviations as well as any impact such deviations shall have on the schedule of work. Failure to address time or other impacts associated with the Contractor's request will be cause for rejection of the Contractor's request. Deviations from the Contract requirements shall not be made unless authorized by the Engineer. If authorized by the Engineer, such authorization shall not relieve the Contractor from the responsibility for complying with the requirements of the Contract for a fully functional finished work item as specified or designed.

If working drawings detailing a change(s) initiated by the Contractor require more than two resubmissions or revisions, the cost of additional reviews by the Department or its designated representative(s) will be assessed to the Contractor.

Upon completion of the work, working drawings indicating the actual as-constructed field conditions, if required or requested, shall be supplied to the Department.

The cost of working drawings furnished by the Contractor shall be included in the cost of appropriate contract items.

The Contractor may authorize the fabricator in writing to act for him in matters relating to working drawings. Such authorization shall have the force and effect of any other representative of the Contractor's organization.

(1) Steel Structures

Working drawings for steel structures, including metal handrails, shall consist of shop detail, erection, and other working drawings showing details, dimensions, sizes of units, and other information necessary for the fabrication and erection of metal work. Such drawings shall be signed and sealed by a Professional Engineer, holding a valid license to practice engineering in the Commonwealth of Virginia.

(2) Falsework

Working drawings for falsework supporting a bridge superstructure shall be signed and sealed by a Professional Engineer, holding a valid license to practice engineering in the Commonwealth of Virginia.

(3) Concrete Structures and Prestressed Concrete Members

Working drawings for concrete structures and prestressed concrete members shall provide such details as required for the successful prosecution of the work and which are not included in the plans furnished by the Department. Drawings shall include plans for items such as prestressing strand details and elongation calculations, location of lift points, falsework, bracing, centering, form work, masonry, layout diagrams and bending diagrams for reinforcing steel when necessary or when requested. Such drawings shall be signed and sealed by a Professional Engineer, holding a valid license to practice engineering in the Commonwealth of Virginia.

(4) Lighting, signal and pedestal poles, overhead and bridge mounted sign structures, breakaway support systems, anchor bolts, framing units, panels, and foundations.

Prior to fabrication or construction, the Contractor shall submit for review one original and six copies of each working drawing and design calculation for lighting, signal and pedestal poles, overhead and bridge mounted sign structures, breakaway support systems, anchor bolts, framing units, panels, and foundations. All sheets of these submittals shall include the Professional Engineer's signature and seal. Certification for foundations will be required only when the designs are furnished by the Contractor. The designs shall be in accordance with the specific editions of the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* as required in Section 700. Such designs shall be signed and sealed by a Professional Engineer, holding a valid license to practice engineering in the Commonwealth of Virginia.

(5) Reinforced Concrete Pipe

When specified, and prior to manufacture of reinforced concrete pipe, the Contractor shall furnish to the Department a certification of the acceptability of the design of such pipe, as determined from a review that has been signed and sealed by a Professional Engineer holding a valid license to practice engineering in the Commonwealth of Virginia. Such certification shall cover

all design data, supporting calculations and materials. Pipe designs previously certified or approved by the Department will not require recertification.

105.11—Conformity with Plans and Specifications

Values for materials to be used in the work shall conform to the specified values or range of values specified in the Contract. Less than complete conformity may be tolerated if obtaining exact or complete conformity would not be feasible and if authorized by the Engineer.

Permissible tolerances for the elevation of subgrade and finished grade, and for the thickness of the various courses of pavement structure are specified in these Specifications. If permissive tolerances are exceeded or if consistent deviations from the plans or abrupt changes in grade occur, even though within the tolerances, the affected areas shall be reconstructed to conform to the specified tolerance and provide a smooth riding surface. When it is not feasible to reconstruct the areas, payment will be made in accordance with the requirements of the applicable specification for each material placed or adjusted in accordance with the provisions of Section 105.18.

When the plans require the finished surface to tie into any structural item whose elevation is fixed, the elevation of the finished surface must coincide with the elevation of the structural item.

105.12—Coordination of Plans, Standard Drawings, Specifications, Supplemental Specifications, Special Provisions, and Special Provision Copied Notes

The plans, Standard Drawings, these Specifications, supplemental specifications, special provisions, special provision copied notes, and supplementary documents are parts of the Contract. These Contract documents are defined in Section 101 - Definitions. A requirement occurring in one shall be as binding as though occurring in all. They are intended to be complementary and to describe and provide for a complete work. In case of a discrepancy, the following order of priority will apply, with the highest governing item appearing first and the least governing item appearing last:

- (a) Special provision copied notes. The pay items and pay units listed in the proposal have the same status as special provision copied notes.
- (b) Special provisions
- (c) Plans
- (d) Supplemental Specifications.
- (e) Specifications
- (f) Standard Drawings. Calculated dimensions, unless obviously incorrect, will govern over scaled dimensions.

Sketches, drawings, general notes and other written information that are not included in special provisions or special provision copied notes used in No Plan and Minimum Plan Concept projects will have the same status as plans.

The Contractor shall not take advantage of any obvious or apparent error or omission in the plans or Specifications. If the Contractor discovers an error or omission, he shall immediately notify the Engineer. The Engineer will then make such corrections and interpretations as may be deemed necessary for fulfilling the intent of the Contract.

105.13—State Force Construction Surveying

(a) **General Description:**

This work shall consist of the Department performing all surveying and providing surveying and stakeout sketches and information as detailed herein for the successful prosecution of work as indicated on the plans and as directed by the Engineer. Stakeout work will be in accordance with the details and requirements of the Department's Survey Manual and the provisions herein. Survey services will be provided to the extent detailed herein for Construction and for Minimum Plan projects.

(b) **Request for Survey Services:**

Once the Contractor requests survey services, the Department will begin the requested work within 3 working days. The Contractor shall not expect the Department survey party to work in the field during adverse weather conditions that could be detrimental to the survey equipment or paperwork, therefore the Contractor shall plan the need for such services accordingly.

It shall be the Contractor's responsibility to preserve all Department furnished centerline or baseline controls, references and location benchmarks. After initial stakeout, an hourly charge equal to the current hourly rate for Department survey services per district will be billed to the Contractor for resetting stakes where the cause for the resetting of such stakes is due to the fault of the Contractor or his operations. This rate will also apply to travel time to and from the project.

If the Contractor requests stakes after the initial staking and he is not ready to accommodate such work, the Contractor will be billed the hourly rate for Department survey services per district measured in travel time to and from the project. Such fees will be billed to the Contractor on the next monthly estimate.

(c) **Contractor Responsibility for Examination of Data:**

It shall be the responsibility of the Contractor to examine all surveying work provided by the Department for accuracy. Should a disagreement involving the accuracy of stakeout or survey work arise during construction, the Contractor shall within 24 hours provide written notice to the Engineer, precisely describing and documenting the discrepancy. The Engineer will determine the validity of the Contractor's assertion in the notice, respond to the Contractor within 3 working days of receipt of the Contractor's notice and provide direction on how to proceed. The Engineer will give consideration to an extension of time in accordance with the requirements of Section 108.04 of the Specifications or provide additional compensation as deemed appropriate after documentation and evidence to the Engineer's satisfaction if the following occurs:

1. There are delays to the project as a result of inaccurate stakeout information provided by the Department where such delays adversely impact the critical path of the work or a controlling item if work or,
2. where extra expense is encountered by the Contractor to correct elements of defective survey work by the Department, and
3. where written notice is provided by the Contractor within the timeframe specified. Failure to furnish written notice of such a discrepancy within the timeframe specified will invalidate any later claim for time impact or costs by the Contractor unless specifically waived by the Engineer.

(d) **Survey Services Furnished:**

1. **Construction (C) Projects:**

a. **Survey Stakeout Descriptions:**

Unless otherwise stated the Department will provide required horizontal and vertical controls for the proper construction stakeout of the project. The Contractor shall preserve all horizontal and vertical controls furnished by the Department.

The following surveying work will be performed by the Department:

- (1) **Digital Terrain Model (DTM) and Construction Cross-Sections:** Original location Digital Terrain Model (DTMs) will be provided by the Department and will serve as a basis of payment for earthwork. The Contractor shall be responsible for taking construction DTMs or cross-sections of areas that, in their determination, do not agree with the Department furnished original location DTMs. The Contractor shall submit the disputed DTM information to the Engineer for verification prior to any excavation by the Contractor in these alleged areas of change. The DTM information furnished by the Department and submitted by the Contractor shall be compatible to the Department's current DTM format.
- (2) **Borrow Pits:** All borrow pit DTM's or cross-sections, originals and finals, will be secured by the Department. The Contractor is encouraged to also secure DTM's or cross-sections of borrow areas. A claim of discrepancy in borrow volume will not be considered by the Engineer unless survey data was obtained and submitted by the Contractor to substantiate his claim.
- (3) **Horizontal and Vertical Control for Bridges:** Certified plats, field notes, coordinates and computations will be furnished to the Contractor by the Department prior to the Contractor beginning work on these structures.
- (5) **Horizontal and Vertical Controls for all Box Culverts, all Pipe Culvert Installations (including single and multiple line installations) with total hydraulic openings equivalent to 12.6 square feet and larger, and for all closed systems such as storm sewers, and sanitary sewers regardless of size:** The Department will stake all such installations. Certified Plats will be furnished to the Contractor prior to the Contractor beginning work on these

culvert structures. The notes, coordinates, or computations used to support the platted information will be furnished to the Contractor with the certified plat. For the purposes of identifying those pipe culvert installations please refer to the areas (hydraulic openings) shown in the PB-1 Standards for the respective sizes of pipes specified on the plans. Where multiple lines of pipes are shown, the areas of the pipe sizes will apply to the total areas of the number of lines specified in the plans. For box culverts refer to the sizes shown in the BC-1 Standards to determine areas of total hydraulic opening.

- (6) **Horizontal and Vertical Control for Pipe Culvert Installations (including single and multiple line installations) having total hydraulic openings equivalent to 3.1 square feet and up to 12.5 square feet:** The Department will be responsible for staking horizontal and vertical control for pipe culvert installations having a total hydraulic opening equivalent to 3.1 square feet and up to 12.5 square feet. Sketches will be furnished to the Contractor prior to the Contractor beginning work on these culvert structures. For the purposes of identifying those pipe culvert installations please refer to the areas (hydraulic openings) shown in the PB-1 Standards for the respective sizes of pipes specified on the plans. Where multiple lines of pipes are shown, the areas of the pipe sizes shall apply to the total areas of the number of lines specified in the plans. For box culverts refer to the sizes shown in the BC-1 Standards to determine areas of total hydraulic opening.
- (7) **Horizontal and Vertical Control for additional centerlines or baselines for roadways, ramps, loops and connections:** Upon written request from the Contractor the Department will provide horizontal and vertical controls for additional centerlines or baselines for roadways, ramps, loops and connections.
- (8) **Grading and paving construction:** The Department will provide fine grade or other grade stakes required for the construction of the project as the work progresses except as stated herein.

Fine grade stakes will be set on all projects on which the plans show a definite grade line. Fine grade hubs will be set on at least one side with distances and grades referenced to the finished centerline grade. Typically, on curves, the Department will provide the distances and elevations to each edge of pavement and centerline through the transitions and the distances and elevations to the edge of pavement only (straight-line super) through full super portions of the curve.

On projects where grading and paving is performed under the same contract, only one set of fine grade stakes will be provided to the Contractor. Fine grade stakes may be used for fine grade and paving grade.

On Secondary Road projects, fine grade stakes will be provided by the Department only on those projects having curb and gutter or as directed by the Engineer.

Special design ditches will be staked with an offset and cut to the centerline of the ditch. Radius points for pavement flares at connections will be staked only if requested by the Contractor.

The Department will set all slope stakes. Upon written request from the Contractor cut/fill sheets for slope stakes will be furnished by the Department to the Contractor within 3 working days of the survey party's arrival at the project site or a timeframe agreed upon by the Contractor and the Engineer after reviewing the length and complexity of the project.

- (9) **Right of way and boundary stakeout affecting property ownership:** Right of Way will be staked by the Department prior to the start of the project. Right of way stakes will be placed at a minimum of 100-foot intervals on each side of the roadway or as directed by the Engineer and the stakes will be marked with both the station and offset back to centerline. All final boundary stakeout will be performed by the Department's survey party.
- (10) **Setting right-of-way monuments:** Final right of way monumentation will be performed by the Department in accordance with the following:
 - a) RM-1: The Department will furnish and install RM-1 right-of-way monuments in accordance with the Road and Bridge Standards.
 - b) RM-2: The Department will furnish and install RM-2 right-of-way monuments and optional locator posts, including the required caps, in accordance with the Road and Bridge Standards.
 - c) Other monumentation: The Department will determine if an alternative form of permanent monumentation will be used if RM-1 or RM-2 monuments are unsuitable for marking the right-of-way at various locations. The Department will indicate this alternative monument usage on the final as-built plan in accordance with the Department's Survey Manual.

Where available, electronic data files along with paper sketches and drawings will be furnished by the Department when requested in writing by the Contractor. All electronic data files furnished to the Contractor will be in the format of the Department's current computer hardware and software or a format fully compatible with such hardware and software.

Additional surveying work and supplemental layout work shall be performed by the Contractor as needed to successfully complete the work. The Contractor shall provide and protect temporary construction benchmarks within the construction limits. Temporary construction benchmarks shall be located not farther than 500 feet apart for the total length of the project or as indicated on the plans. Temporary construction benchmarks that are disturbed during construction operations shall be reestablished by the Contractor at no additional cost to the Department. All drawings, field notes, and computations from such survey work performed by the Contractor shall be submitted to the Engineer.

2. Minimum Plan (M) Projects:

a. **Survey Stakeout Descriptions:**

Unless otherwise stated, the Department will provide required horizontal and vertical control for the proper construction stakeout of the project. The Contractor shall preserve all horizontal and vertical controls furnished by the Department.

The following surveying work will be performed by the Department:

- (1) **Digital Terrain Model (DTM) and Construction Cross-Sections:** “M” projects are based on plan quantities; therefore DTM and construction cross-sections are not required, except for borrow pits.

Should the Engineer determine at any time that an actual measurement is warranted, the Department will make the necessary measurement in the field.

- (2) **Borrow Pits:** All borrow pit DTM’s, originals and finals, will be secured by the Department. The Contractor is encouraged to also secure DTM’s or cross-sections of borrow areas. A claim of discrepancy in borrow volume will not be considered by the Engineer unless survey data was obtained by the Contractor to substantiate his claim.
- (3) **Horizontal and vertical control for bridges:** Certified plats, field notes, coordinates and computations will be furnished to the Contractor prior to the Contractor beginning work on these structures.
- (4) **Horizontal and Vertical Control for all Box Culverts, all Pipe Culvert Installations (including single and multiple line installations) with a total hydraulic openings equivalent to 12.6 square feet and larger, and for all closed systems such as storm sewers, and sanitary sewers regardless of size:** The Department will stake all such installations. Certified Plats for these stakeouts will be furnished to the Contractor prior to the Contractor beginning work on these culvert structures. The notes, or computations used to support the platted information will be furnished to the Contractor with the certified plat. For the purposes of identifying those pipe culvert installations please refer to the areas (hydraulic openings) shown in the PB-1 Standards for the respective sizes of pipes specified on the plans. Where multiple lines of pipes are shown, the areas of the pipe sizes will apply to the total areas of the number of lines specified in the plans. For box culverts refer to the sizes shown in the BC-1 Standards to determine areas of total hydraulic openings.
- (5) **Horizontal and Verticals Control for Pipe Culvert installations (including single and multiple line installations) having total hydraulic openings equivalent to 3.1 square feet and up to 12.5 square feet:** The Department will be responsible for staking horizontal and vertical controls for pipe culvert installations having a total hydraulic opening equivalent to 3.1 square feet and up to 12.5 square feet. Sketches will be furnished to the Contractor prior to the Contractor beginning work on these culvert structures. For the purposes of identifying those pipe culvert installations please refer to the areas (hydraulic openings) shown in the PB-1 Standards for the respective sizes of pipes specified on the plans. Where multiple lines of pipes are shown, the areas of the pipe sizes will apply to the total areas of the number

of lines specified in the plans. For box culverts refer to the sizes shown in the BC-1 Standards to determine areas of total hydraulic opening.

- (6) **Grading and paving construction:** The Department will provide fine grade or other grade stakes required for the construction of all projects except as stated herein as the work progresses. Slope stakes are not required on “M” projects

Fine grade stakes will be set on all projects on which the plans show a definite grade line. Fine grade hubs will be set on at least one side with distances and grades referenced to the finished centerline grade. Typically, on curves, the Department will provide the distances and elevations to each edge of pavement and centerline through the transitions and the distances and elevations to the edge of pavement only (straight-line super) through full super portions of the curve.

On projects where grading and paving is performed under the same contract, only one set of fine grade stakes will be provided by the Department. Fine grade stakes may be used for fine grade and paving grade.

On Secondary Road projects, fine grade stakes will be provided by the Department only on those projects having curb and gutter or as directed by the Engineer.

Special design ditches will be staked with an offset and cut to the centerline of the ditch. Radius points for pavement flares at connections will be staked only if requested by the Contractor.

- (7) **Right of way and boundary stakeout affecting property ownership:** Right of Way will be staked by the Department prior to the start of the job. Right of way stakes will be placed at a minimum of 100-foot intervals on each side of the roadway or as directed by the Engineer and the stakes will be marked with both the station and offset back to centerline. All final boundary stakeout will be performed by the Department survey party.
- (8) **Setting right-of-way monuments:** Final right of way monumentation will be performed by the Department in accordance with the following:
- a) RM-1: The Department will furnish and install RM-1 right-of-way monuments in accordance with the Road and Bridge Standards.
 - b) RM-2: The Department will furnish and install RM-2 right-of-way monuments and optional locator posts, including the required caps, in accordance with the Road and Bridge Standards.
 - c) Other monumentation: The Department will determine if an alternative form of permanent monumentation will be used if RM-1 or RM-2 monuments are unsuitable for marking the right-of-way at various locations. The Department will indicate this alternative monument usage on the final as-built plan in accordance with the Department’s Survey Manual.

105.14—Maintenance During Construction

The Contractor shall prosecute his work so as to avoid obstructions to traffic to the greatest extent practicable. The Contractor shall provide for the safety and convenience of the general public and residents along the roadway and the protection of persons and property.

Highways closed to traffic shall be protected by barricades and other warning devices as required by the Engineer. Barricades and warning devices shall be illuminated where required during periods of darkness and low visibility. The Contractor shall erect warning devices in advance of a location on the project where operations or obstructions may interfere with the use of the road by traffic and at all intermediate points where the new work crosses or coincides with an existing roadway. The Contractor shall maintain sign faces and reflective surfaces of warning devices in a clean and visible condition. The Contractor shall cover or remove signs when the messages thereon are not applicable. Barricades, warning signs, lights, temporary signals, and other protective devices shall conform to the requirements of Section 512.

The Contractor shall maintain the work from the beginning of construction operations until final acceptance. Maintenance shall be inherent to the continuous and effective work prosecuted day by day with adequate equipment and forces to such end that the roadway and structures are sustained in a safe and satisfactory condition at all times.

When a Contract specifies placing a course on another course or subgrade previously constructed, the Contractor shall maintain the previous course or subgrade in accordance with the contract requirements during all construction operations.

The road shall be kept open to all traffic while undergoing improvements, unless otherwise permitted in the Contract. The Contractor shall keep the portion of the project being used by public, pedestrian, and vehicular traffic in such condition that traffic will be safely and adequately accommodated. However, removal of snow and control of ice on roads open to public travel will be performed by the Department.

The Contractor shall bear all costs of performing maintenance work before final acceptance and of constructing and maintaining necessary approaches, crossings, intersections, and other features without direct compensation except as provided for herein. When the Contractor confines his operation to the surface of the roadway and reasonable width of the shoulder and the surface is disturbed or damaged by his operations or equipment, he shall be responsible for the restoration and maintenance of the surface that is disturbed or damaged.

The Contractor shall keep the portions of the road being used by the public free from irregularities and obstructions that could present a hazard or annoyance to traffic. When directed by the Engineer, allaying of dust shall be performed and paid for in accordance with the requirements of Section 511. Holes in hard surface pavements shall be filled with approved asphalt patching material.

- (a) **Detours:** Detours may be indicated on the plans or in the special provisions or may be used with the approval of the Engineer. Unless otherwise designated in the contract, the Contractor will furnish and erect all directional markings for through traffic on off-project detours authorized or requested by the Engineer. Detours over existing state roads will be designated, marked, and maintained by the Contractor. If any project is located wholly or in part within the corporate limits of a municipality and through traffic is to be detoured at the request of the municipality, the municipality will provide and maintain the detours within the corporate limits and will furnish and erect all directional markings. The provision of detours

and marking of alternate routes will not relieve the Contractor of the responsibility for ensuring the safety of the public or from complying with any requirements of these Specifications affecting the rights of the public within his contract limits, including those concerning lights and barricades. Maintenance of all other detours shall be the responsibility of the Contractor.

Right of way for temporary highways, diversion channels, sediment and erosion control features or bridges required by these provisions will be furnished by the Department.

- (b) **Maintenance of Traffic During Suspension of Work:** During any suspension of work, the Contractor shall temporarily open to traffic such portions of the project and temporary roadways as may be agreed upon by the Contractor and Engineer.
- (c) **Flagging Traffic:** Certified flaggers shall be provided in sufficient number and locations as necessary for control and protection of vehicular and pedestrian traffic in accordance with the requirements of the *Virginia Work Area Protection Manual (VWAPM)*. Flaggers shall be able to communicate to the traveling public in English while performing the job duty as a flagger at the flagger station. Flaggers shall use sign paddles to regulate traffic in accordance with the requirements of the *VWAPM*.

Certification for flaggers will be awarded upon a candidate's satisfactory completion of an examination. Certification cards shall be carried by flaggers while performing flagging duties. Flaggers found not to be in possession of their certification card shall be removed from the flagging site and operations requiring flagging will be suspended by the Engineer. Further, flaggers performing duties improperly will have their certifications revoked.

- (d) **Delays:** Unless indicated in the Contract Documents or otherwise approved by the Engineer, two-way traffic shall be maintained at all times. The Contractor shall not stop traffic without permission of the Engineer.

If one-way traffic is approved, the Contractor shall provide flaggers to direct the traffic. When specified in the Contract as a pay item, pilot vehicles shall be furnished in accordance with the requirements of Section 512. Upon request from the Contractor and where deemed appropriate by the Department, the Department will install traffic signals that may be used for the control of one-way traffic. The Contractor shall pay the costs of installation, electrical service, maintenance or repair work, and a predetermined rental charge per day for the signals and removal when no longer needed.

- (e) **Connections and Entrances:** Connections with other roads and public and private entrances shall be kept in a reasonably smooth condition at all times.

Stabilization or surfacing material shall be applied to connections and entrances. When specified in the Contract, such material will be paid for at the contract unit price for the specific material. Where such material is not specified in the Contract and determined to be required by the Engineer, the cost for stabilization or surfacing material will be handled in accordance with the provisions of Section 109.05.

The Contractor shall schedule construction operations so that approved continuous access is provided for all property adjacent to the construction when the property is shown on the plans to require access. When frontage roads are shown on the plans, they shall be con-

structed prior to the closing of any access routes unless other approved access is provided and is acceptable to the property owner.

Connections or entrances shall not be disturbed by the Contractor until necessary. Once connections or entrances have been disturbed, they shall be maintained and completed as follows:

1. **Connections:** Connections that had an original paved surface shall be brought to a grade that will smoothly and safely accommodate vehicular traffic through the intersection, using temporary pavement as soon as practicable after connections are disturbed. Connections that had an original unpaved surface shall be brought to a grade that will smoothly and safely accommodate vehicular traffic through the intersection, using either the required material or a temporary aggregate stabilization course that shall be placed as soon as practicable after connections are disturbed.

If there are delays in prosecution of work for connections, connections that were originally paved shall have at least two lanes maintained with a temporary paved surface. Those that were not originally paved shall be maintained with a temporary aggregate stabilization course.

2. **Entrances:** Entrances shall be graded concurrently with the roadway with which they intersect. Once an entrance has been disturbed, it shall be completed as soon as is practicable, including placing the required base and surface course or stabilization. If the entrance must be constructed in stages, such as when there is a substantial change in the elevation of the roadway with which it intersects, the surface shall be covered with a temporary aggregate stabilization course or other suitable salvaged material until the entrance can be completed and the required base and surface or stabilization course can be placed.
- (f) **Grading Operations:** When the Contractor elects to complete the rough grading operations for the entire project or exceed the length of one full day's surfacing operations, the rough grade shall be machined to a uniform slope from the top edge of the existing pavement to the ditch line.

When the surface is to be widened on both sides of the existing pavement, construction operations involving grading or paving shall not be conducted simultaneously on sections directly opposite each other.

The surface of pavement shall be kept free from soil and other materials that might be hazardous to traffic. Prior to opening of new pavement to traffic, shoulders shall be roughly dressed for a distance of 3 feet from the edge of the paved surface.

- (g) **Obstruction Crossing Roadways:** Where the Contractor places obstructions such as suction or discharge pipes, pump hoses, steel plates or any other obstruction that must be crossed by vehicular traffic, they shall be bridged as directed by the Engineer at the Contractor's expense. Traffic shall be protected by the display of warning devices both day and night. If operations or obstructions placed by the Contractor damage an existing traveled roadway, the Contractor shall cease operations and repair damages to the roadway at no additional cost to the Department.

- (h) **Patching Operations:** Where existing hydraulic cement concrete pavement is to be patched, the operation of breaking and excavating old pavement shall extend for a distance of not more than two miles. Patching shall be coordinated with excavating so that an area of not more than one-half mile in which excavated patches are located shall be left at the end of any day's work. Necessary precautions shall be taken to protect traffic during patching operations.
- (i) **Temporary Structures:** The Contractor shall construct, maintain, and remove temporary structures and approaches necessary for use by traffic. Unless otherwise specified in the Contract, the cost of these operations shall be included in pay items for the new structure. After new structures have been opened to traffic, temporary structures and approaches shall be removed. The materials contained therein shall remain the property of the Contractor.

The proposed design of temporary structures shall be submitted to the Engineer prior to the beginning of construction in accordance with the requirements of Section 105.10.

- (j) **Failure To Maintain Roadway or Structures:** If the Contractor fails to remedy unsatisfactory maintenance immediately after receipt of a notice by the Engineer, the Engineer may proceed with adequate forces, equipment, and material to maintain the project. The cost of the maintenance, plus 25 percent for supervisory and administrative personnel, will be deducted from monies due the Contractor for the project.
- (k) **Haul Route:** The Contractor shall select haul routes between the project and material source(s) that will minimize disturbance to the community. The Contractor shall furnish to the Engineer, for review, his plan for the haul route and for minimizing the adverse effects of hauling operations on persons who reside adjacent to the haul route or persons who otherwise use a portion of the haul route for ingress or egress to their residential or work area. The Department may select alternate haul routes, divide the hauling traffic over several routes, and impose other restrictions deemed necessary to minimize the impact of the hauling operation on local residents.
- (l) **Opening Sections of Projects to Traffic**

When specified in the Contract or when directed by the Engineer, certain sections of the work may be opened to traffic. Such opening shall not constitute acceptance of the work or any part thereof or a waiver of any provision of the Contract.

On any section of the work opened by order of the Engineer where the Contract does not provide for traffic to be carried through the work the Contractor will not be required to assume any expense entailed in maintaining the road for traffic. Such expense will be borne by the Department or will be compensated for in accordance with the requirements of Section 109.05. Repair of slides and repair of damage attributable to traffic will be compensated for in accordance with the requirements of Section 109.05. Slides shall be removed by the Contractor in accordance with the requirements of Section 303.

On any section of the work opened by order of the Engineer where the Contract does not provide for traffic to be carried through the work, any additional cost for the completion of other items of work that are required because of the changed working conditions will be compensated in accordance with the requirements of Section 109.05.

If the Contractor is not continuously prosecuting the work to the satisfaction of the Engineer, he shall not be relieved of the responsibility for maintenance during the period the section is opened to traffic prior to final acceptance. Any expense resulting from the opening of such portions under these circumstances, except slides, shall be borne by the Contractor. The Contractor shall conduct the remainder of the construction operations so as to cause the least obstruction to traffic.

105.15—Removing and Disposing of Structures and Obstructions

The Contractor shall remove and dispose of or store, as directed by the Engineer, fences, buildings, structures, or encumbrances within the construction limits unless separate pay items for this work are included in the Contract. Payment for these operations will be in accordance with the requirements of Section 301.03. Materials so removed, including existing drains or pipe culverts, shall become the property of the Contractor, with the exception of those materials to be stored or delivered to the Department or others as designated in the Contract.

- (a) **Signs:** The Contractor shall relocate all signs within the construction limits that conflict with construction work as approved by the Engineer. Signs that are not needed for the safe and orderly control of traffic during construction as determined by the Engineer shall be removed and stored at a designated location within the project limits. The removed signs shall be stored above ground in a manner that will preclude damage and shall be reinstalled in their permanent locations prior to final acceptance. If any of the removed signs are not to be reinstalled, the Contractor shall notify the Engineer at the time the signs have been properly stored. Such signs will be removed from the storage area by the Department. Any sign that is damaged or lost because of the fault of the Contractor shall be repaired or replaced at his expense. Costs for removing, storing, protecting, and reinstalling such signs shall be included in the price bid for other items in the Contract, and no additional compensation will be made.
- (b) **Mailboxes and Newspaper Boxes:** When removal of mailboxes and newspaper boxes is made necessary by construction operations, the Contractor shall place them in temporary locations so that access to them will not be impaired. Prior to final acceptance, boxes shall be placed in their permanent locations as designated by the Engineer and left in as good condition as when found. Boxes or their supports that are damaged through negligence on the part of the Contractor shall be replaced at his expense. The cost of removing and resetting boxes shall be as specified in the Contract.

105.16—Cleanup

Removal from the project of rubbish, scrap material, and debris caused by the Contractor's personnel or construction operations shall be a continuing process throughout the course of the work. The work site shall have a neat, safe and orderly appearance at all times.

Before final acceptance, the highway, borrow pits, quarries, disposal areas, storage areas, and all ground occupied by the Contractor in connection with the work shall be cleaned of rubbish, surplus materials, and temporary structures, except in the case where the property is owned or controlled by the Contractor. All parts of the work shall be left in a neat, safe and orderly condition.

Within 30 days after final acceptance, the Contractor shall remove his equipment, materials and debris from the right of way and property adjacent to the project that he does not own or control.

105.17—Inspection of Work

Inspection will be performed at critical stages. However, all stages, materials, and details of the work are subject to inspection. The Contractor shall provide the Engineer and Inspectors with full and safe access to all parts of the work and shall be furnished such information and assistance by the Contractor as are required to make a complete, timely and detailed inspection. The Engineer and his appointed representatives shall have ready access to machines and plant equipment used in processing or placing materials.

Prior to the beginning of operations, the Engineer will meet with the Contractor to establish an understanding of the critical stages of work that shall be performed in the presence of the Inspector. In order for the Department to schedule inspection of the work, the Contractor shall keep the Engineer informed of planned operations in accordance with the requirements of Section 108.03

If the Engineer requests it, the Contractor shall remove or uncover such portions of the finished work as may be directed at any time before final acceptance. The Contractor shall restore such portions of the work to comply with the appropriate contract specification requirements. If the work exposed is acceptable, the uncovering or removing and replacing the covering or making good the parts removed will be paid for as extra work in accordance with the requirements of Section 104.03. If the work is unacceptable, the cost of uncovering or removing and replacing the covering or making good the parts removed shall be borne by the Contractor.

When any unit of government, political subdivision, or public or private corporation is to pay a portion of the cost of the work specified in the Contract, its representatives shall have the right to inspect the work. The exercise of this right shall not be construed as making them a party or parties to the Contract or conferring on them the right to issue instructions or orders to the Contractor.

If materials are used or work is performed without inspection by an authorized representative of the Department, the Contractor may be ordered to remove and replace the work or material at his own expense unless the Department's representative failed to inspect the work or material after having been given reasonable notice in writing that the material was to be used or the work was to be performed.

If an inspection reveals that work has not been properly performed, the Contractor will be so advised and he shall immediately inform the Department of his schedule for correcting such work and the time when a reinspection can be made.

105.18—Removal of Unacceptable and Unauthorized Work

Work that does not conform to the requirements of the Contract will be considered unacceptable work.

Unacceptable work shall be remedied or removed as determined by the Engineer and replaced in an acceptable manner at the Contractor's expense. The Engineer may accept the work at a reduced price when acceptance is considered to be in the best interest of the public.

Work that is done contrary to the instructions of the Engineer, contrary to the requirements of the Contract, beyond the lines shown on the plans or as designated by the Engineer except as specified herein, or without authority will be considered unauthorized and will not be paid for. Such work may be ordered removed or replaced at the Contractor's expense.

The Contractor shall not perform destructive sampling or testing of the work without written authorization of the Engineer. Unauthorized destructive sampling or testing will cause the work to be considered unacceptable.

In the event the Contractor is granted authorization to perform destructive sampling or testing, the Contractor shall obtain the approval of the Engineer for the method and location of each test prior to beginning such sampling or testing. In addition, destructive sampling and testing shall be performed in the presence of the Engineer.

If the Contractor fails to comply immediately with any order of the Engineer made under the provisions of this Section, the Engineer will have the authority to cause unacceptable work to be removed and replaced and to deduct the cost from any monies due or to become due the Contractor.

105.19—Submission and Disposition of Claims

Early or prior knowledge by the Department of an existing or impending claim for damages could alter the plans, scheduling, or other action of the Department or result in mitigation or elimination of the effect of the act objected to by the Contractor. Therefore, a written statement describing the act of omission or commission by the Department or its agents that allegedly caused damage to the Contractor and the nature of the claimed damage shall be submitted to the Engineer at the time of each and every occurrence that the Contractor feels gives it the right to make a claim or prior to the beginning of the work upon which a claim and any subsequent action will be based. The written statement shall clearly inform the Department that it is a "notice of intent to file a claim." If such damage is deemed certain in the opinion of the Contractor to result from his acting on an order from the Engineer, he shall immediately take written exception to the order. Submission of a notice of intent to file a claim as specified shall be mandatory. Failure to submit such notice of intent shall be a conclusive waiver to such claim for damages by the Contractor. An oral notice or statement will not be sufficient nor will a notice or statement after the event.

In addition, at the time of each and every occurrence that the Contractor feels gives it the right to make a claim or prior to beginning the work upon which a claim and any subsequent action will be based, the Contractor shall furnish the Engineer an itemized list of materials, equipment, and labor for which additional compensation will be claimed. Only actual cost for materials, labor and equipment will be considered. The Contractor shall afford the Engineer every facility for keeping an actual cost record of the work. The Contractor and the Engineer shall compare records and bring them into agreement at the end of each day. Failure on the part of the Contractor to afford the Engineer proper facilities for keeping a record of actual costs will constitute a waiver of a claim for such extra compensation except to the extent that it is substantiated by the Department's records. The filing of such notice of intent by the Contractor and the keeping of cost records by the Engineer shall in no way establish the validity of a claim.

Upon completion of the Contract, the Contractor may, within 60 days after the final estimate date established by the Department pursuant to Virginia Code, § 33.1-386, deliver to the Department a written claim, which must be a signed original claim document along with three legible copies of the claim document, for the amount he deems he is entitled to under the Contract. For the purpose of this

Section, the final estimate date shall be that date set forth in a letter from the Department to the Contractor sent by certified mail and shall be considered as the date of notification of the Department's final estimate. Regardless of the manner of delivery of the claim, the Department must receive and have physical possession of the Contractor's written claim within the 60 day period that commences with the final estimate date. Submittals received by the Department either before the final estimate date or after the 60 day period shall not have standing as a claim. The claim shall set forth the facts upon which the claim is based. The Contractor shall include all pertinent data and correspondence that may substantiate the claim. Only actual cost for materials, labor and equipment will be considered. If the Contractor makes a claim, the Department shall have the right, at its expense, to review and copy all of the Contractor's non-privileged project files and documents, both electronic and paper, for use in analyzing the claim. Within 90 days from the receipt of the claim, the Department will make an investigation and notify the Contractor by certified mail of its decision. However, by mutual agreement, the Department and Contractor may extend the 90-day period for another 30 days.

If the Contractor is dissatisfied with the decision, he shall notify the Commissioner in writing within 30 days from receipt of the Department's decision that he desires to appear before him, whether in person or through counsel, and present additional facts and arguments in support of his claim. The Commissioner will schedule and meet with the Contractor within 30 days after receiving the request. However, the Commissioner and Contractor, by mutual agreement, may schedule the meeting to be held after 30 days but before the 60th day from the receipt of the Contractor's written request. Within 45 days from the date of the meeting, the Commissioner will investigate the claim, including the additional facts presented, and notify the Contractor in writing of his decision. However, the Commissioner and Contractor, by mutual agreement, may extend the 45-day period for another 30 days. If the Commissioner deems that all or any portion of a claim is valid, he shall have the authority to negotiate a settlement with the Contractor subject to any approvals required by the *Code of Virginia*.

Any monies that become payable as the result of claim settlement after payment of the final estimate will not be subject to payment of interest unless such payment is specified as a condition of the claim settlement.

The Contractor shall submit a certification with any claim using the following format:

Pursuant to *Code of Virginia*, I hereby certify that this contract claim submission for Virginia Department of Transportation Project _____ in _____ County, Virginia is a true and accurate representation of additional costs and/or delays incurred by (name of Contractor) in the performance of the required contract work. Any statements made, and known to be false, shall be considered a violation of the Virginia Governmental Frauds Act, punishable as allowed by the Virginia Code for a Class 6 Felony.

(Company)

By:

As officer or duly appointed agent of (Company)

Title:

Date:

State Of:

City/County of _____, To-Wit:

I, the undersigned, a Notary Public in and for the City/ County and State aforesaid, do hereby certify that _____, whose name is signed to the foregoing instrument, bearing date of the _____ day of _____, 20____, has this day acknowledged the same before me in my City/ County and State aforesaid.

Given under my hand this day of, 20____.

Notary Public:

My commission expires:

Claims submitted during the statutory period for submitting contract claims and submitted without the certification described above shall not have standing as a claim and shall not be considered by the Department.

SECTION 106—CONTROL OF MATERIAL

106.01—Source of Supply and Quality Requirements

The materials used throughout the work shall conform to the requirements of the Contract. The Contractor shall regulate his supplies so that there will be a sufficient quantity of tested material on hand at all times to prevent any delay of work. Except as otherwise specified, materials, equipment, and components that are to be incorporated into the finished work shall be new. Within 30 days after notification of award of the Contract, but not later than 7 days prior to the beginning of construction operations under the Contract, the Contractor shall file a statement of the known origin, composition and manufacture of all materials to be used in the work, including optional or alternate items. Material requirements not previously reported shall be submitted at least 60 days prior to their use on the project, but not less than two weeks prior to delivery. The Contractor’s statement shall be electronically submitted by use of Form C-25 and shall be identified by the complete project number, and all items or component materials shall be identified by the specific contract item number and the Specification reference shown in the Contract.

At the option of the Engineer, materials may be approved at the source of supply. If it is found during the life of the Contract that previously approved sources of supply do not supply materials or equipment conforming to the requirements of the Contract, do not furnish the valid test data required to document the quality of the material or equipment, or do not furnish documentation to validate quantities to document payment, the Contractor shall change the source of supply and furnish material or equipment from other approved sources. The Contractor shall notify the Department of this change, and provide the same identifying information noted in this Section, at least 60 days prior to their use on the project, but not less than two weeks prior to delivery.

Materials shall not contain toxic, hazardous, or regulated solid wastes or be furnished from a source containing toxic, hazardous or regulated solid wastes.

When optional materials are included in the Contract, the Contractor shall advise the Engineer in writing of the specific materials selected. Thereafter, the Contractor shall use the selected materials

throughout the project unless a change is authorized in writing by the Engineer. However, when the Contractor has an option as to the type of pipe that may be used, he may use any of the approved types for each size of pipe, but he shall use the same type for a particular line. The Engineer may authorize other types and sources in an emergency that will not unreasonably delay delivery of the selected material.

Equipment and material guaranties or warranties that are normally given by a manufacturer or supplier, or are otherwise required in the Contract, shall be obtained by the Contractor and assigned to the Commonwealth in writing. The Contractor shall also provide an in-service operation guaranty on all mechanical and electrical equipment and related components for a period of at least six months, beginning on the date of partial acceptance of that specific item(s) or final acceptance of the project.

106.02—Material Delivery

The Contractor shall advise the Engineer at least 2 weeks prior to the delivery of any material from a commercial source. Upon delivery of any such material to the project, the Contractor shall provide the Engineer with one copy of all invoices (prices are not required). The following materials shall also comply with the requirements of Section 109.01: asphalt concrete; dense graded aggregate, to include aggregate base, subbase, and select material; fine aggregate; open graded coarse aggregate; crusher run aggregate; and road stabilization aggregate. The printed weights of each load of these materials, as specified in Section 109.01, shall accompany the delivery, and such information shall be furnished to the Inspector at the project.

106.03—Local Material Sources (Pits and Quarries)

The requirements set forth herein apply exclusively to non-commercial pits and quarries from which materials are obtained for use on contracts awarded by the Department.

Local material sources shall be concealed from view from the completed roadway and any existing public roadway. Concealment shall be accomplished by selectively locating the pit or quarry and spoil pile, providing environmentally compatible screening between the pit or quarry site and the roadway, or using the site for another purpose after removal of the material, or restoration equivalent to the original use (such as farm land, pasture, turf, etc.). The foregoing requirements shall also apply to any pit or quarry opened or reopened by a subcontractor or supplier. However, the requirements will not apply to commercial sand and gravel and quarry operations actively processing material at the site prior to the date of the Notice of Advertisement.

The Contractor shall furnish the Engineer a statement signed by the property owner in which the property owner agrees to the use of his property as a source of material for the project. Upon completion of the use of the property as a material source, the Contractor shall furnish the Engineer a release signed by the property owner indicating that the property has been satisfactorily restored. This requirement will be waived for commercial sources, sources owned by the Contractor, and sources furnished by the Department.

Local material pits and quarries that are not operated under a local or State permit shall not be opened or reopened without authorization by the Engineer. The Contractor shall submit for approval a site plan, including, but not limited to, the following

- (1) the location and approximate boundaries of the excavation;

- (2) procedures to minimize erosion and siltation;
- (3) provision of environmentally compatible screening;
- (4) restoration;
- (5) cover vegetation;
- (6) other use of the pit or quarry after removal of material, including the spoil pile;
- (7) the drainage pattern on and away from the area of land affected, including the directional flow of water and a certification with appropriate calculations that verify all receiving channels are in compliance with Minimum Standard 19 of the Virginia Erosion and Sediment Control Regulations;
- (8) location of haul roads and stabilized construction entrances if construction equipment will enter a paved roadway;
- (9) constructed or natural waterways used for discharge;
- (10) a sequence and schedule to achieve the approved plan and;
- (11) the total drainage area for temporary sediment traps and basins shall be shown. Sediment traps are required if the runoff from a watershed area of less than three acres flows across a disturbed area. Sediment basins are required if the runoff from a watershed area of three acres or more flows across a disturbed area. The Contractor shall certify that the sediment trap or basin design is in compliance with VDOT Standards and Specifications, and all local, state, and federal laws. Once a sediment trap or basin is constructed, the dam and all outfall areas shall be immediately stabilized.

The Contractor's design and restoration shall be in accordance with the Contract requirements and in accordance with the requirements of the federal, state, and local laws and regulations.

If the approved plan provides for the continued use or other use of the pit or quarry beyond the date of final acceptance, the Contractor shall furnish the Department a bond made payable to the Commonwealth of Virginia in an amount equal to the Engineer's estimate of the cost of performing the restoration work. If the pit or quarry is not used in accordance with the approved plan within 8 months after final acceptance, the Contractor shall perform restoration work as directed by the Engineer, forfeit his bond, or furnish the Engineer with evidence that he has complied with the applicable requirements of the State Mining Law.

Topsoil on Department owned or furnished borrow sites shall be stripped and stockpiled as directed by the Engineer for use as needed within the construction limits of the project or in the reclamation of borrow and disposal areas.

If payment is to be made for material measured in its original position, material shall not be removed until Digital Terrain Model (DTM) or cross-sections have been taken. The material shall be reserved exclusively for use on the project until completion of the project or until final DTM or cross-sections have been taken.

If the Contractor fails to provide necessary controls to prevent erosion and siltation, if such efforts are not made in accordance with the approved sequence, or if the efforts are found to be inadequate the Department will withdraw approval for the use of the site and may cause the Contractor to cease all contributing operations and direct his efforts toward corrective action or may perform the work with state forces or other means as determined by the Engineer. If the work is not performed by the Contractor, the cost of performing the work, plus 25 percent for supervisory and administrative personnel, will be deducted from monies due the Contractor.

Costs for applying seed, fertilizer, lime, and mulch; restoration; drainage; erosion and siltation control; regrading; haul roads; and screening shall be included in the Contract price for the type of excavation or other appropriate items.

If the Contractor fails to fulfill the provisions of the approved plan for screening or restoring material sources, the Department may withhold and use for the purpose of performing such work any monies due the Contractor at the time of the final estimate. The Contractor shall be held liable for penalties, fines, or damages incurred by the Department as a result of his failure to prevent erosion or siltation and take restorative action.

After removing the material, the Contractor shall remove metal, lumber, and other debris resulting from his operations and shall shape and landscape the area in accordance with the approved plan for such work.

- (a) **Sources Furnished by the Department:** Sources furnished by the Department will be made available to the Contractor together with the right to use such property as may be required for a plant site, stockpiles, and haul roads. The Contractor shall confine his excavation operations to those areas of the property specified in the Contract.

The Contractor shall be responsible for excavation that shall be performed in order to furnish the specified material.

- (b) **Sources Furnished by the Contractor:** When the Contractor desires to use local material from sources other than those furnished by the Department, he shall first secure the approval of the Engineer. The use of material from such sources will not be permitted until test results have been approved by the Engineer and written authority for its use has been issued.

The Contractor shall acquire the necessary rights to take material from sources he locates and shall pay all related costs, including costs that may result from an increase in the length of the haul. Costs of exploring, sampling, testing, and developing such sources shall be borne by the Contractor. The Contractor shall obtain representative samples from at least two borings in parcels of 10 acres or less and at least three additional borings per increment of 5 acres or portion thereof to ensure that lateral changes in material are recorded. Drill logs for each test shall include a soil description and the moisture content at intervals where a soil change is observed or at least every 5 feet of depth for consistent material. Samples obtained from the boring shall be tested by an approved laboratory for grading, Atterberg limits, CBR, maximum density, and optimum moisture. The Department will review and evaluate the material based on test results provided by the Contractor. The Department will reject any material from a previously approved source that fails a visual examination or whose test results show that it does not conform to the Specifications or specific contract requirements.

106.04—Disposal Areas

Unsuitable or surplus material shown on the plans shall be disposed of as specified herein. Material not used on the project shall be disposed of by the Contractor off the right of way. The Contractor shall obtain the necessary rights to property to be used as an approved disposal area. For the purpose of this Specification an approved disposal area is defined as that which is owned privately, not operated under a local or State permit and has been approved by the Department for use in disposing of material not used on the project.

When neither unsuitable nor surplus material is shown on the plans, the Contractor shall dispose of it as shown herein. If the Contractor, having shown reasonable effort, is unsuccessful in obtaining the necessary rights to property to be used as an approved disposal area, the Department will obtain rights for disposal unless otherwise provided for in the contract. Compensation, if not shown in the Contract, will be in accordance with the requirements of Section 104.02.

Prior to the Department approving a disposal area, the Contractor shall submit a site plan. The plan shall show:

- (1) the location and approximate boundaries of the disposal area;
- (2) procedures to minimize erosion and siltation;
- (3) provision of environmentally compatible screening;
- (4) restoration;
- (5) cover vegetation;
- (6) other use of the disposal site;
- (7) the drainage pattern on and away from the area of land affected, including the directional flow of water and a certification with appropriate calculations that verify all receiving channels are in compliance with Minimum Standard 19 of the Virginia Erosion and Sediment Control Regulations;
- (8) location of haul roads and stabilized construction entrances if construction equipment will enter a paved roadway;
- (9) constructed or natural waterways used for discharge;
- (10) a sequence and schedule to achieve the approved plan and;
- (11) the total drainage area for temporary sediment traps and basins shall be shown. Sediment traps are required if the runoff from a watershed area of less than three acres flows across a disturbed area. Sediment basins are required if the runoff from a watershed area of three acres or more flows across a disturbed area. The Contractor shall certify that the sediment trap or basin design is in compliance with VDOT Standards and Specifications, all local, state, and federal laws. Once a sediment trap or basin is constructed, the dam and all outfall areas shall be immediately stabilized.

Disposal areas shall be cleared but need not be grubbed. The clearing work shall not damage grass, shrubs, or vegetation outside the limits of the approved area and haul roads thereto. After the material has been deposited, the area shall be shaped to minimize erosion and siltation of nearby streams and landscaped in accordance with the approved plan for such work or shall be used as approved by the Engineer. The Contractor's design and restoration shall conform to the requirements of the contract and federal, state, and local laws and regulations.

If the Contractor fails to provide and maintain necessary controls to prevent erosion and siltation, if such efforts are not made in accordance with the approved sequence, or if the efforts are found to be inadequate, the Department will withdraw approval for the use of the site and may cause the Contractor to cease all contributing operations and direct his efforts toward corrective action or may perform the work with state forces or other means as determined by the Engineer. If the work is not performed by the Contractor, the cost of performing the work, plus 25 percent for supervisory and administrative personnel, will be deducted from monies due the Contractor.

The Contractor shall furnish the Engineer a statement signed by the property owner in which the owner agrees to the use of his property for the deposit of material from the project. Upon completion of the use of the property as an approved disposal area, the Contractor shall furnish the Engineer a release signed by the property owner indicating that the property has been satisfactorily restored. This requirement will be waived for commercial sources, sources owned by the Contractor, and sources furnished by the Department.

Material encountered by the Contractor shall be handled as follows:

- (a) **Unsuitable material** for the purpose of this Specification is defined as material having poor bearing capacity, excessive moisture content, extreme plasticity or other characteristics as defined by the Engineer that makes it unacceptable for use in the work and shall be disposed of at an approved disposal area or landfill licensed to receive such material.
- (b) **Surplus material** as shown on the plans shall be disposed of by flattening slopes, used to fill in ramp gores and medians, or if not needed, disposed of at an approved disposal area or a landfill licensed to receive such material.

Surplus material stockpile areas on the right-of-way shall be cleared but need not be grubbed. The clearing work shall not damage grass, shrubs, or vegetation outside the limits of the approved area and the haul roads thereto. Placement of fill material shall not adversely affect existing drainage structures. If necessary, modified existing drainage structures, as approved by the Engineer, shall be paid for in accordance with Section 109.05. Within 7 days after the material has been deposited, the area shall be shaped and stabilized to minimize erosion and siltation.

- (c) **Organic materials** such as, but not limited to, tree stumps and limbs (not considered merchantable timber), roots, rootmat, leaves, grass cuttings, or other similar materials shall be chipped or shredded and used on the project as mulch, given away, sold as firewood or mulch, burned at the Contractor's option if permitted by local ordinance, or disposed of at a facility licensed to receive such materials. Organic material shall not be buried in state rights of way or in an approved disposal area.
- (d) **Rootmat** for the purpose of this Specification is defined as any material that, by volume, contains approximately 60 percent or more roots and shall be disposed of in accordance with (c) herein.

- (e) **Inorganic materials** such as brick, cinder block, broken concrete without exposed reinforcing steel, or other such material may be used in accordance with Section 303.04 or shall be disposed of at an approved disposal area or landfill licensed to receive such materials. If disposed of in an approved disposal area, the material shall have enough cover to promote soil stabilization in accordance with the requirements of Section 303 and shall be restored in accordance with other provisions of this Section.

Concrete without exposed reinforcing steel, may be crushed and used as rock in accordance with Section 303. If approved by the Engineer, these materials may be blended with soils that meet AASHTO M57 requirements and deposited in fill areas within the right-of-way in accordance with the requirements of Section 303 as applicable.

- (f) **Excavated rock** in excess of that used within the project site in accordance with the requirements of Section 303 shall be treated as surplus material.
- (g) **Other materials** such as, but not limited to, antifreeze, asphalt (liquid), building forms, concrete with reinforcing steel exposed, curing compound, fuel, hazardous materials, lubricants, metal, metal pipe, oil, paint, wood or metal from building demolition, or similar materials shall not be disposed of at an approved disposal area but shall be disposed of at a landfill licensed to receive such material.

106.05—Rights for and Use of Materials Found on Project

With the approval of the Engineer, the Contractor may use in the project any materials found in the excavation that comply with the requirements of the Specifications. Unless otherwise specified, the Contractor will be paid for both the excavation of such materials at the contract unit price and for the pay item for which the excavated material is used. However, the Contractor shall replace at his own expense with other acceptable material the excavation material removed and used that is needed for use in embankments, backfills, approaches, or otherwise. The Contractor shall not excavate or remove any material from within the construction limits that is not within the grading limits, indicated by the typical section, slope and grade lines shown in the plans without written authorization by the Engineer.

106.06—Samples, Tests, and Cited Specifications

Materials will be inspected and tested by the Engineer before or during their incorporation in the work. However, the inspection and testing of such material shall not relieve the Contractor of the responsibility for furnishing material that conforms to the requirements of the Specifications. The Department may retest all materials that have been accepted at the source of supply after delivery and will reject those that do not conform to the requirements of the Specifications. Stored material may be re-inspected prior to use. Work in which untested materials are used without the written permission of the Engineer may be considered unacceptable.

Unless reference is made to a specific dated Specification, references in these Specifications to AASHTO, ASTM, VTM, and other standard test methods and materials requirements shall refer to either the test specifications that have been formally adopted or the latest interim or tentative specifications that have been published by the appropriate committee of such organizations as of the date of the Notice of Advertisement. Unless otherwise indicated, tests for compliance with specification requirements will be made by and at the Department's expense except that the cost of retests, exclusive

of the first retest, shall be borne by the Contractor. Samples shall be furnished by the Contractor at his expense, and those that are not tested by the Contractor will be tested by a representative of the Department.

The inspection cost of structural steel items fabricated in a country other than the continental United States shall be borne by the Contractor. Inspection of structural fabrication shall be performed in accordance with the requirements of the appropriate VTM by a commercial laboratory approved by the Department. Additional cleaning or repair necessary because of environmental conditions in transit shall be at the Contractor's expense.

In lieu of testing, the Engineer may approve the use of materials based on the receipt of a certification furnished by the Contractor from the manufacturer. However, furnishing the certificate shall not relieve the Contractor of the responsibility for furnishing materials that conform to the requirements of the Specifications or the contract requirements.

Materials requiring an MSDS will not be accepted at the project site for sampling or at the Department's laboratories for testing without the document.

106.07—Plant Inspection

If the Engineer inspects materials at the source, the following conditions shall be met:

- (a) The Engineer shall have the cooperation and assistance of the Contractor and producer of the materials.
- (b) The Engineer shall have full access to parts of the plant that concern the manufacture or production of the materials being furnished.
- (c) For materials accepted under a quality assurance plan, the Contractor or producer shall furnish equipment and maintain a plant laboratory at locations approved for plant processing of materials. The Contractor or producer shall use the laboratory and equipment to perform quality control testing.

The laboratory shall be of weatherproof construction, tightly floored and roofed, and shall have adequate lighting, heating, running water, ventilation, and electrical service. The ambient temperature shall be maintained between 68 degrees F and 86 degrees F and thermostatically controlled. The laboratory shall be equipped with a telephone, intercom, or other electronic communication system connecting the laboratory and scale house if the facilities are not in close proximity to each other. The laboratory shall be constructed in accordance with the requirements of local building codes.

The Contractor or producer shall furnish, install, maintain, and replace, as conditions necessitate, testing equipment specified by the appropriate ASTM, AASHTO method or VTM being used and provide necessary office equipment and supplies to facilitate keeping records and generating test reports. The Contractor or producer's technician shall maintain current copies of test procedures performed in the laboratory. The Contractor shall calibrate or verify all balances, scales and weights associated with testing performed as specified in AASHTO R18. The Contractor or producer shall also provide and maintain an approved test stand for accessing truck beds for the purpose of sampling and inspection. The Department

may approve a single laboratory to service more than one plant belonging to the same Contractor or producer.

For crushed glass, the plant equipment requirements are waived in lieu of an independent third-party evaluation and certification of crushed glass properties by an AASHTO Materials Reference Laboratory (AMRL)-accredited commercial soil testing laboratory demonstrating that the supplied material conforms to the specified requirements of Section 203. Random triplicate samples will be evaluated and analyzed for every 1,000 tons of material supplied to the project. The averaged results will be used for evaluation purposes. Suppliers of crushed glass shall maintain third party certification records for a period of three years.

106.08—Storing Materials

Materials shall be stored in a manner so as to ensure the preservation of their quality and fitness for the work. When considered necessary by the Engineer, materials shall be stored in weatherproof buildings on wooden platforms or other hard, clean surfaces that will keep the material off the ground. Materials shall be covered when directed by the Engineer. Stored material shall be located so as to facilitate their prompt inspection. Approved portions of the right of way may be used for storage of material and equipment and for plant operations. However, equipment and materials shall not be stored within the clear zone of the travel lanes open to traffic.

Additional required storage space shall be provided by the Contractor at his expense. Private property shall not be used for storage purposes without the written permission of the owner or lessee. The Contractor shall furnish copies of the owner's written permission to the Engineer. Upon completion of the use of the property, the Contractor shall furnish the Engineer a release signed by the property owner indicating that the property has been satisfactorily restored.

Chemicals, fuels, lubricants, bitumens, paints, raw sewage, and other harmful materials as determined by the Engineer shall not be stored within any floodplain unless no other location is available and only then shall the material be stored in a secondary containment structure(s) with an impervious liner. Also, any storage of these materials in proximity to natural or man-made drainage conveyances or otherwise where the materials could potentially reach a waterway if released under adverse weather conditions, must be stored in a bermed or diked area or inside a container capable of preventing a release. Double-walled storage tanks shall meet the berm/dike containment requirement except for storage within flood plains. Any spills, leaks or releases of such materials shall be addressed in accordance with Section 107.16(b). Accumulated rain water may also be pumped out of the impoundment area into approved dewatering devices.

106.09—Handling Materials

Materials shall be handled in a manner that will preserve their quality, integrity and fitness for the work. Aggregates shall be transported in vehicles constructed to prevent loss or segregation of materials.

106.10—Unacceptable Materials

Materials that do not conform to the requirements of the Specifications shall be considered unacceptable. Such materials, whether in place or not, will be rejected and shall be removed from the site of

106.10

the work. If it is not practical for the Contractor to remove rejected material immediately, the Engineer will mark the material for identification. Rejected material whose defects have been corrected shall not be used until approval has been given by the Engineer.

106.11—Material Furnished by the Department

The Contractor shall furnish all materials required to complete the work except those specified to be furnished by the Department.

Material furnished by the Department will be delivered or made available to the Contractor at the points specified in the Contract. The cost of handling and placing materials after delivery to the Contractor shall be included in the contract price for the item with which they are used.

After receipt of the materials, the Contractor shall be responsible for material delivered to him, including shortages, deficiencies, and damages that occur after delivery, and any demurrage charges.

106.12—Critical Materials

Raw, manufactured materials or supplies that are necessary for the fabrication, construction, installation or completion of any item of work that is, or becomes, in extremely short supply regionally or nationally as substantiated by recognized public reports such as news media, trade association journals, etc. due to catastrophic events of nature, needs of national defense or industrial conditions beyond the control of the Department or Contractor, will be declared Critical by the Department.

When the supply of materials becomes critical, the provisions of this Section will become applicable to the Contract.

When all items of work involving noncritical materials have been completed by the Contractor or have progressed to a point where no further work is practicable prior to receipt of critical materials, a complete suspension of work will be granted by the Department. Requests for partial suspension orders because of delays attributable to nonreceipt of critical materials will be considered on the basis of merit in each case.

The Department reserves the right to substitute materials by means of a work order.

Contractors, via their manufacturers or suppliers, that request relief due to critical shortage of materials as specified in this Section shall immediately supply information concerning the product and other supporting data to permit the Department an opportunity to access possible alternatives or methods to avoid undue delay or expenditure.

SECTION 107—LEGAL RESPONSIBILITIES

107.01—Laws To Be Observed

The Contractor shall keep fully informed of federal, state, and local laws, bylaws, ordinances, orders, decrees, and regulations of governing bodies, courts, and agencies having any jurisdiction or authority

that affects those engaged or employed on the work, the conduct of the work, or the execution of any documents in connection with the work. The Contractor shall observe and comply with such laws, ordinances, regulations, orders, or decrees and shall indemnify and hold harmless the Commonwealth and its agents, officers, or employees against any claim for liability arising from or based on their violation, whether by himself, his agents, his employees, or subcontractors. The Contractor shall execute and file the documents, statements, and affidavits required under any applicable federal or state law or regulation required by or affecting his bid or Contract or prosecution of the work there under. The Contractor shall permit examination of any records made subject to such examination by any federal or state law or by regulations promulgated there under by any state or federal agency charged with enforcement of such law.

In accordance with the *Code of Virginia* (Virginia Public Procurement Act), the Contractor shall make payment to all subcontractors, as defined in the Code, within seven days after receipt of payment from the Department; or shall notify the Department and subcontractor in writing of his intention to withhold all or a part of the amount due along with the reason for nonpayment.

In the event payment is not made as noted, the Contractor shall pay interest at the rate of 1 percent per month, unless otherwise provided in the Contract, to the subcontractor on all amounts that remain unpaid after seven days except for the amounts withheld as provided in this Section.

These same requirements shall be included in each subcontract and shall be applicable to each lower-tier subcontractor.

107.02—Permits, Certificates, and Licenses

General

The Contractor shall conform to the permit conditions as shown in the contract documents. Construction methods shall conform to the stipulations of the permit and/or certification conditions. The Contractor shall assume all obligations and costs incurred as a result of complying with the terms and conditions of the permits and certificates.

If any of the permits shown herein are applicable to the project, the contract documents will indicate such and the applicable permit conditions will be included in the contract documents.

- (a) **Department of the Army, Corps of Engineers Nationwide Permits:** A nationwide permit is issued to the Department by the U.S. Army Corps of Engineers to place fill or dredge material in waters of the United States including wetlands.
- (b) **The State Program General Permit for Linear Transportation Projects (SPGP- 01 2A & B):** The SPGP-01 2A & B is a permit issued to the Department by the U.S. Army Corps of Engineers to proceed with linear transportation projects involving work, structures and filling both temporary and permanent, in waters of the United States including wetlands.
- (c) **Letter of Permission (LOP-1):** The LOP-1 is a regional permit issued to the Department by the U.S. Army Corps of Engineers to proceed with roadway projects involving work, structures and filling both temporary and permanent, in waters of the United States including wetlands.

- (d) **Virginia Marine Resources Commission – Virginia General Permit (VGP-1):** A VGP-1 permit is issued to the Department by the Virginia Marine Resources Commission and is required on projects that cross in, on or over state-owned land which is submerged below low water (channelward of the mean low water line), in tidal areas including tidal wetlands, or below ordinary high water anywhere in the Commonwealth of Virginia.
- (e) **Virginia Water Protection Permit (VWPP):** The VWPP is issued to the Department by the Virginia Department of Environmental Quality, Water Division and is required for activities that result in a discharge to surface waters and wetlands. The VWPP is issued as an individual or general permit.
- (f) **Virginia Stormwater Management Program General/Stormwater Management Permit (VSMP):** The VSMP permit is issued by the Virginia Department of Conservation and Recreation and is required for all construction activities in accordance with Section 107.16. The general VSMP permit covers the discharges from the site during construction. The Department will be responsible for acquiring the VSMP permit from the Virginia Department of Conservation and Recreation for the project.
- (g) **Coastal Zone Management (CZM) Consistency Concurrence:** This clearance is issued to the Department by the Virginia Department of Environmental Quality for projects in navigable waters requiring a U.S. Coast Guard bridge permit.
- (h) **Tennessee Valley Authority (TVA) Permit:** The TVA Section 26a permit is issued to the Department by the Tennessee Valley Authority and is required for construction activities in or along the Tennessee River or its tributaries.
- (i) **U.S. Coast Guard Bridge Permit:** This permit is required for bridge projects over navigable waters. The Department is responsible for acquiring these permits.
- (j) **Other Permits, Certificates and Licenses:** Except as otherwise specified herein, the Contractor shall procure all necessary permits, certificates or licenses that have not been obtained by the Department. The Contractor shall pay all charges, fees, and taxes and shall comply with all conditions of the permits, certificates or licenses.

Construction or excavation material shall not be stored within the waterway or wetlands. Cofferdams, stream channel retaining structures and all necessary dikes shall be constructed of non-erodible materials or if specified in the permit(s), faced with coarse non-erodible materials. If faced with non-erodible material, filter cloth shall be placed between the granular fill and riprap in accordance with Section 245, 204, 303.03 and 414. Temporary structures shall be removed from the waterway with minimal disturbance of the streambed. Discharge of dredge or fill material shall be placed in accordance with the best management practice, project permits and all applicable laws and regulations. Dredged or fill material shall be removed to an approved, contained, upland location in accordance with Section 106.04. The disposal area will be of sufficient size and capacity to properly contain the dredge material, to allow for adequate dewatering and settling of sediment, and to prevent overtopping. The disposal area shall be stabilized prior to placement of dredge material.

The Contractor activities shall not substantially disrupt the movement of those species of aquatic life indigenous to the water body including those species that normally migrate through the area. The Contractor to the maximum extent practicable shall not permanently restrict or impede the passage of normal or expected high flows or cause the relocation of the water. The Contractor shall avoid and minimize all temporary disturbances to surface waters during construction. The Contractor shall re-

move any temporary fill in its entirety and the affected areas returned to their preexisting elevation conditions within 30 days of completing work, which shall include re-establishing pre-construction contours, and planting or seeding with appropriate wetland vegetation according to cover type (emergent, scrub/shrub, or forested). The Contractor shall perform all work activities during low-flow conditions and shall isolate the construction area via the implementation of nonerodible cofferdams, sheetpiling, stream diversions or similar structures.

The Contractor shall accomplish all construction, construction access (e.g., cofferdams, sheetpiling, and causeways) and demolition activities associated with this project in a manner that minimizes construction or waste materials from entering surface waters. Access roads and associated bridges or culverts shall be constructed to minimize the adverse effects on surface waters. Access roads constructed above preconstruction contours and elevations in surface waters must be bridged or culverted to maintain surface flows. All utility line work in surface waters shall be performed in a manner that minimizes disturbance, and the area shall be returned to its original contours and restored within 30 days of completing work in the area.

The Contractor shall prepare and implement an erosion and sediment control plan in compliance with the Erosion and Sediment Control Law, the Erosion and Sediment Control Regulations, and the annual erosion and sediment control standards and specifications approved by the Department of Conservation and Recreation. The Contractor shall stockpile excavated material in a manner that prevents reentry into the stream, restores original streambed and streambank contours, revegetates barren areas, and implements strict erosion and sediment control measures throughout the project period as described in the Virginia Department of Transportation Annual Program approved by the Virginia Department of Conservation and Recreation.

The Contractor shall comply with the Stormwater Management Act, the Stormwater Management Regulations, and the annual storm water management standards and specifications approved by the Department of Conservation and Recreation. The Contractor shall provide fill material that is clean and free of contaminants in toxic concentrations or amounts in accordance with all applicable laws and regulations. The Contractor shall comply with all applicable FEMA-approved state or local floodplain management requirements.

The Contractor shall adhere to any time-of-year restriction conditions as required by state and federal permitting agencies. No in-stream work shall be permitted during in-stream time-of-year restriction.

The Contractor shall prohibit wet or uncured concrete from entry into flowing surface waters. The Contractor shall not dispose of excess or waste concrete in surface waters and prevent wash water from discharging into surface waters. The Contractor shall employ measures to prevent spills of fuels or lubricants into state waters.

The Contractor shall not violate the water quality standards as a result of the construction activities. The Contractor shall not alter the physical, chemical, or biological properties of surface waters and wetlands or make them detrimental to the public health, to animal or aquatic life, to the uses of such waters for domestic or industrial consumption, for recreation, or for other uses.

The Contractor shall not proceed with work covered by a permit until the work is released in writing by the Engineer.

If the Department has not released work covered by a U.S. Army Corps of Engineers permit and the Contractor has completed all other work within the limits of the project, the Contractor shall so advise the Engineer in writing. Upon receipt of the notification, the Engineer will evaluate the status of the

project and advise the Contractor within 45 days of the portion of the project that is acceptable under Section 108.09. If the Engineer determines that all of the work except that encumbered by the permit application is acceptable under the requirements of Section 108.09, the Contractor will be notified accordingly. The Department or the Contractor may then elect to continue or terminate the remaining portion of the Contract.

The party electing to terminate the Contract shall so advise the other party in writing after the 45-day period. The terms of contract termination will be in accordance with the requirements of Section 108.08. No compensation will be made for delays encountered or for work not performed except for an extension of time as determined in accordance with the requirements of Section 108.04.

The Contractor shall submit a request to the Engineer in writing if he wants to deviate from the plans or change his proposed method(s) regarding any proposed work located in waterways or wetlands. Such work may require additional environmental permits. If the Engineer determines that the activities are necessary for completion of the work, the Contractor shall furnish the Engineer all necessary information pertaining to the activity. The Contractor shall be responsible for designing and supplying all sketches and notes necessary to acquire any permit modification required for changes in the proposed construction methods. Such information shall be furnished at least 180 days prior to the date the proposed changed activity is to begin. The District Environmental Manager will apply for the necessary permits modifications to the permits obtained by the Department. The Contractor shall not begin the activity until directed to do so by the Engineer. Additional compensation will not be made for delay to the work or change in the Contractor's proposed methods that result from jurisdiction agency review or disapproval of Contractor's proposed methods.

If additional permits are required to perform dredging for flotation of construction equipment or for other permanent or temporary work as indicated in the Contractor's accepted plan of operation, but have not been obtained by the Department, the Contractor shall furnish the Engineer, at least 75 days prior to the proposed activity, all necessary information pertaining to the proposed activity in order for the Department to apply for the permits. The Contractor shall not begin the proposed activity until the additional permits have been secured and the Engineer has advised the Contractor that the proposed activity may proceed.

The Contractor shall permit representatives of state and federal environmental regulatory agencies to make inspections at any time in order to insure that the activity being performed under authority of the permit(s) is in accordance with the terms and conditions prescribed herein.

107.03—Federal-Aid Provisions

When the U.S. government pays all or any portion of the cost of a project, the Contractor shall comply with the federal laws and rules and regulations made pursuant to such laws. The work shall be subject to inspection by the appropriate federal agency. Such inspection shall in no sense make the federal government a party of the Contract and will in no way interfere with the rights of either party to the Contract.

107.04—Furnishing Right of Way

The Department will secure necessary rights of way and easements in advance of construction. The Department will not be responsible for any delay in the acquisition of a right of way other than consideration of an extension of time. The Department will provide notification of known delays in the

proposal for work to assist bidders in planning the work and composing their bids. Easements for temporary uses and detours requested by the Contractor and approved by the Department in lieu of a detour within the right of way or easement area shall be acquired by the Contractor without the Department being a party to the agreement.

107.05—Patented Devices, Materials, and Processes

If the Contractor employs any design, device, material, or process covered by a patent or copyright outside the requirements of the Contract he shall provide for its use by obtaining a legal agreement with the patentee or owner. The Contractor and the surety shall indemnify and save harmless the Commonwealth, any affected third party, or political subdivision from claims for infringement because of such use. The Contractor shall indemnify the Commonwealth for costs, expenses, or damages resulting from infringement during prosecution or after completion of the work.

107.06—Personal Liability of Public Officials

In carrying out any of the provisions of these Specifications or in exercising any power or authority granted to them by or within the scope of the Contract, there shall be no liability upon the Board, Commissioner, Engineer, or their authorized representatives, either personally or as officials of the Commonwealth. In all such matters, they act solely as agents and representatives of the Commonwealth.

107.07—No Waiver of Legal Rights

The Commonwealth shall not be precluded or estopped by any measurement, estimate, or certificate made either before or after final acceptance of the work and payment therefor from showing (1) the true amount and character of the work performed and materials furnished by the Contractor, (2) that any such measurement, estimate, or certificate is untrue or incorrectly made, or (3) that the work or materials do not comply with the provisions of the Contract. The Commonwealth shall not be precluded or estopped, notwithstanding any such measurement, estimate, or certificate, and payment in accordance therewith, from recovering from the Contractor or his surety, or both, such damage as it may sustain by reason of his failure to comply with the terms of the Contract. Neither the acceptance by the Department or any representative of the Department nor any payment for or acceptance of the whole or any part of the work, nor any extension of time, nor any possession taken by the Department shall operate as a waiver of any portion of the Contract or of any power herein reserved or of any right to damages. A waiver of any breach of the Contract shall not be held to be a waiver of any other or subsequent breach.

107.08—Protecting and Restoring Property and Landscape

The Contractor shall preserve property and improvements along the boundary lines of and adjacent to the work unless their removal or destruction is specified in the Contract Documents. The Contractor shall use suitable precautions to prevent damage to such property.

When the Contractor finds it necessary to enter on private property, beyond the limits of the construction easement shown on the plans, he shall secure from the owner or lessee a written permit for such entry prior to moving thereon. An executed copy of this permit shall be furnished to the Engineer.

The Contractor shall be responsible for any damage or injury to property during the prosecution of the work resulting from any act, omission, neglect, or misconduct in the Contractor's method of executing the work or attributable to defective work or materials. This responsibility shall not be released until final acceptance of the project and a written release from the owner or lessee of the property is obtained.

When direct or indirect damage is done to property by or on account of any act, omission, neglect, or misconduct in the Contractor's method of executing the work or in consequence of the nonexecution thereof on the part of the Contractor, the Contractor shall restore such property to a condition similar or equal to that existing before such damage was done by repairing, rebuilding, or restoring, as may be directed by the Engineer, or making settlement with the property owner. The Contractor shall secure from the owner a release from any claim against the Department without additional compensation therefor. A copy of this release shall be furnished the Engineer.

107.09—Contractor's Responsibility for Utility Property and Services

At points where the Contractor's operations are on or adjacent to the properties of any utility, including railroads, and damage to which might result in expense, loss, or inconvenience, work shall not commence until arrangements necessary for the protection thereof have been completed.

The Contractor shall cooperate with owners of utilities so that removal and adjustment operations may progress in a timely, responsible, and reasonable manner, duplication of adjustment work may be reduced to a minimum, and services rendered by those parties will not be unnecessarily interrupted.

If any utility service is interrupted as a result of accidental breakage or of being exposed or unsupported, the Contractor shall promptly notify the proper authority and shall cooperate fully with the authority in the restoration of service. If utility service is interrupted, repair work shall be continuous until service is restored. No work shall be undertaken around fire hydrants until provisions for continued service have been approved by the local fire authority. When the Contractor's work operations require the disconnection of "in service" fire hydrants, the Contractor shall notify the locality's fire department or communication center at least 24 hours prior to disconnection. In addition, the Contractor shall notify the locality's fire department or communications center no later than 24 hours after reconnection of such hydrants. The Contractor shall be responsible for any damage to utilities that, in the investigation and determination of the Engineer, is found to be attributable to the Contractor's neglect, means or methods of performing the work.

Nothing in this Section shall be construed to be in conflict with the provisions of Section 107.08.

The Contractor shall comply with all requirements of the *Virginia Underground Utility Damage Prevention Act* (the Miss Utility law). The Contractor shall wait a minimum of 48 hours after notifying the Miss Utility notification center before commencing excavation work. The Contractor may commence excavation work after 48 hours only if confirmed through the Ticket Information Exchange (TIE) System that all applicable utilities have either marked their underground line locations or reported that no lines are present in the work vicinity. The Contractor shall wait an additional 24 hours before commencing excavation operations if any utility operators have failed to respond to the TIE within the first 48 hours.

107.10—Restoration of Work Performed by Others

The Department may construct or reconstruct any utility service within the construction limits or grant a permit for the same at any time. The Contractor shall not be entitled to any damages occasioned thereby other than a consideration of an extension of time, unless the Contractor's Work is damaged, altered or impeded by the condition.

When authorized by the Engineer, the Contractor shall allow any person, firm, or corporation to make an opening in the highway within the limits of the project upon presentation of a duly executed permit from the Department or any municipality for sections within its corporate limits. When directed by the Engineer, the Contractor shall satisfactorily repair portions of the work disturbed by the openings. The work for such repairs as authorized and directed by the Engineer will be paid for in accordance with the requirements of Section 109.05 and shall be subject to the same conditions as the original work performed.

107.11—Use of Explosives

Explosives shall be stored and used in a secure manner in compliance with federal, state, and local laws and ordinances. Prior to prosecuting the work, the Contractor shall conduct an on-site review of the work involved and develop a plan of operations for performing excavation work. Where feasible, the Contractor shall explore other means of loosening and or reducing the size of the excavation without blasting. When blasting becomes necessary, the Contractor's plan of operations shall include a blasting plan detailing the blasting techniques to be used during excavation operations requiring the use of explosives. Both plans shall be submitted to the Engineer for review prior to commencing blasting operations.

The Contractor shall be responsible for damage resulting from the use of explosives. The Contractor shall notify each property and utility owner having a building, structure, or other installation above or below ground in proximity to the site of the work of his intention to use explosives. Notice shall be given sufficiently in advance of the start of blasting operations to enable the owners to take steps to protect their property. The review of the Contractor's plan of operations, blasting plan and the notification of property owners shall in no way relieve the Contractor of his responsibility for damage resulting from his blasting operations.

107.12—Responsibility for Damage Claims

The Contractor shall indemnify and save harmless the Commonwealth, the Board, and its officers, agents, and employees, and the city, town, county, or other municipality in which the work is performed and their officers, agents, and employees, from suits, actions, or claims brought for or on account of any injuries or damages received or sustained by any person, persons, or property resulting from or arising out of the work performed by the Contractor, or by or in consequence of any neglect in safeguarding the work, through the use of unacceptable materials in the construction or the improvement, or resulting from any act or omission, neglect, or misconduct of the Contractor; or by or on account of any claims or amounts recovered by infringement of any patent, trademark, or copyright. The Commissioner may retain as much of the monies due the Contractor under and by virtue of his Contract as the Commonwealth considers necessary to ensure that a fund will be available to pay a settlement or judgment of such suits, actions, or claims. If no monies are due, the Contractor's surety will be held accountable until all such claims and actions have been settled and suitable evidence to

that effect has been furnished the Board. Any extension of time granted the Contractor, in which to complete the Contract shall not relieve him or his surety of this responsibility.

It is not intended by any of the provisions of any part of the Contract to establish the public or any member thereof as a third party beneficiary hereunder, or to authorize anyone not a party to the Contract to enter into a suit for personal injuries or property damage pursuant to the terms or provisions of the Contract.

The Contractor shall comply with all requirements, conditions, and terms of the Contract, including but not limited to, environmental permits, commitments identified in the Contract, and applicable environmental laws and regulations. The Contractor shall not cause damage, except as allowed under the terms of the Contract, or as allowed under applicable permits or laws, to the air, water, or other natural resources, or cause damage to adjacent or off-site property.

When any act, omission, or other action of the Contractor occurs, that violates the requirements, conditions or terms of the Contract, and affects the health, safety, or welfare of the public or natural resources, the Engineer will direct the Contractor to take prompt action to repair, replace, or restore the damage or injury within a time frame established by the Engineer, and to comply with the requirements of Section 107.01. If the Contractor fails to make such repair, replacement, or restoration within the established time frame, the Engineer will have the damage or injury repaired, replaced, or restored and will deduct the cost of such repair, replacement, or restoration from monies due the Contractor.

If the Department determines by its own investigation that injury or damage has occurred as a result of work performed or neglected by the Contractor, the Department may suspend the Contractor from future bidding for a period of time commensurate with the severity of the injury or damage as determined by the Chief Engineer. Injury is defined as harm or impairment to persons or natural resources. Damage is defined as the loss or harm resulting from injury to person or property. In addition, the Department may recover either (i) the loss or damage that the Department suffers as a result of such act, omission or other action or (ii) any liquidated damages established in such contract plus (iii) reasonable attorney's fees, expert witness fees, staff salaries, incidental and equipment charges associated with any investigation.

Upon a finding against the Contractor by the Department, the Contractor shall be responsible for and shall reimburse the Department for all expenses associated with the injury or damage. Expenses include, but are not limited to: costs for investigating the act, omission or other action, financial penalties incurred by the Department as a result of the injury or damage, salary and expenses incurred by employees or consultants of the Commonwealth, road user expenses as determined by the Department due to damage or loss of use of the project area, attorney fees, and expert witness fees. The Department may deduct the reimbursement of expenses from any payments owed the Contractor.

Upon determination by the Department of willful, flagrant or repetitious acts, omissions or other actions related to injury or damage to person or property, the Contractor shall be responsible for and shall reimburse the Department for all expenses associated with the investigation as shown herein, and the Department will impose other appropriate actions, as permitted by law, policy and Specifications, such as but not limited to, suspension of work, termination for cause, removal from the bidders' list.

Once a determination is made that injury or damage has resulted in an action against the Contractor, the Contractor shall have the right of appeal in accordance with the provisions and requirements of Section 105.19.

Should any cost remain in dispute after appeal, resolution shall be handled in accordance with the provisions and requirements of Section 105.19.

107.13—Labor and Wages

The Contractor shall comply with the provisions and requirements of the workers' compensation law and public statutes that regulate hours of employment on public work.

- (a) **Predetermined Minimum Wages:** The provisions of laws requiring the payment of a minimum wage of a predetermined minimum wage scale for the various classes of laborers and mechanics, when such a scale is incorporated in the Contract, shall be expressly made a part of any Contract hereunder. The Contractor and his agents shall promptly comply with all such applicable provisions.

Any classification not listed and subsequently required shall be classified or reclassified in accordance with the wage determination. If other classifications are used, omission of classifications shall not be cause for additional compensation. The Contractor shall be responsible for determining local practices with regard to the application of the various labor classifications.

- (b) **Labor Rate Forms:** The Contractor shall complete Form C-28, indicating by classification the total number of employees, excluding executive and administrative employees, employed on the project. The Contractor shall also indicate on the form the compensation rate per hour for each classification. The Contractor shall submit an original and two copies of the form prior to the due date of the second estimate for payment and for each 90-day period thereafter until the work specified in the Contract has been completed.

If at the time of final acceptance the period since the last labor report is 30 days or more, the Contractor shall furnish an additional labor report as outlined herein prior to payment of the final estimate.

107.14—Equal Employment Opportunity

The Contractor shall comply with the applicable provisions of presidential executive orders and the rules, regulations, and orders of the President's Committee on Equal Employment Opportunity.

The Contractor shall maintain the following records and reports as required by the contract EEO provisions:

- (a) record of all applicants for employment
- (b) new hires by race, work classification, hourly rate, and date employed
- (c) minority and non-minority employees employed in each work classification
- (d) changes in work classifications
- (e) employees enrolled in approved training programs and the status of each

- (f) minority subcontractor or subcontractors with meaningful minority group representation
- (g) copies of Form C-57 submitted by subcontractors

If the Contract has a stipulation or requirement for trainees, the Contractor shall submit semiannual training reports in accordance with the instructions shown on the forms furnished by the Department. If the Contractor fails to submit such reports in accordance with the instructions, his monthly progress estimate for payment may be delayed.

The Contractor shall cooperate with the Department in carrying out EEO obligations and in the Department's review of activities under the Contract. The Contractor shall comply with the specific EEO requirements specified herein and shall include these requirements in every subcontract of \$10,000 or more with such modification of language as may be necessary to make them binding on the subcontractor.

- (a) **EEO Policy:** The Contractor shall accept as operating policy the following statement:

It is the policy of this Company to assure that applicants are employed and that employees are treated during employment without regard to their race, religion, sex, color, or national origin. Such action shall include employment, upgrading, demotion, or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship or on-the-job training.

- (b) **EEO Officer:** The Contractor shall designate and make known to the Department an EEO Officer who can effectively administer and promote an active contractor EEO program and who shall be assigned adequate authority and responsibility to do so.

- (c) **Dissemination of Policy:**

1. Members of the Contractor's staff who are authorized to hire, supervise, promote, and discharge employees or recommend such action or are substantially involved in such action shall be made fully aware of and shall implement the Contractor's EEO policy and contractual responsibilities to provide equal employment opportunity in each grade and classification of employment. The following actions shall be taken as a minimum:
 - a. Periodic meetings of supervisory and personnel office employees shall be conducted before the start of work and at least once every 6 months thereafter, at which time the Contractor's EEO policy and its implementation shall be reviewed and explained. The meetings shall be conducted by the EEO Officer or another knowledgeable company official.
 - b. New supervisory or personnel office employees shall be given a thorough indoctrination by the EEO Officer or another knowledgeable company official covering all major aspects of the Contractor's EEO obligations within 30 days following their reporting for duty with the Contractor.
 - c. The EEO Officer or appropriate company official shall instruct employees engaged in the direct recruitment of employees for the project relative to the methods followed by the Contractor in locating and hiring minority group employees.

2. In order to make the Contractor's EEO policy known to all employees, prospective employees, and potential sources of employees such as, but not limited to, schools, employment agencies, labor unions where appropriate, and college placement officers, the Contractor shall take the following actions:

a. Notices and posters setting forth the Contractor's EEO policy shall be placed in areas readily accessible to employees, applicants for employment, and potential employees.

The Contractor shall furnish, erect, and maintain at least two bulletin boards having dimensions of at least 48 inches in width and 36 inches in height at locations readily accessible to all personnel concerned with the project. The boards shall be erected immediately upon initiation of the contract work and shall be maintained until the completion of such work, at which time they shall be removed from the project. Each bulletin board shall be equipped with a removable glass or plastic cover that when in place will protect posters from weather or damage. The Contractor shall promptly post official notices on the bulletin boards. The costs for such work shall be included in the price bid for other contract items.

b. The Contractor's EEO policy and the procedures to implement such policy shall be brought to the attention of employees by means of meetings, employee hand-books, or other appropriate means.

(d) Recruitment:

1. When advertising for employees, the Contractor shall include in all advertisements for employees the notation "An Equal Opportunity Employer" and shall insert all such advertisements in newspapers or other publications having a large circulation among minority groups in the area from which the project work force would normally be derived.

2. Unless precluded by a valid bargaining agreement, the Contractor shall conduct systematic and direct recruitment through public and private employee referral sources likely to yield qualified minority group applicants, including, but not limited to, state employment agencies, schools, colleges, and minority group organizations. The Contractor shall identify sources of potential minority group employees and shall establish procedures with such sources whereby minority group applicants may be referred to him for employment consideration.

3. The Contractor shall encourage his employees to refer minority group applicants for employment by posting appropriate notices or bulletins in areas accessible to all employees. In addition, information and procedures with regard to referring minority group applicants shall be discussed with employees.

(e) Personnel Actions: Wages, working conditions, and employee benefits shall be established and administered, and personnel action of any type shall be taken without regard to race, color, religion, sex, or national origin.

1. The Contractor shall conduct periodic inspections of project sites to ensure that working conditions and employee facilities do not indicate discriminatory treatment of personnel.

2. The Contractor shall periodically evaluate the spread of wages paid within each classification to determine whether there is evidence of discriminatory wage practices.
3. The Contractor shall periodically review selected personnel actions in depth to determine whether there is evidence of discrimination. Where evidence is found, the Contractor shall promptly take corrective action. If the review indicates that the discrimination may extend beyond the actions reviewed, corrective action shall include all affected persons.
4. The Contractor shall investigate all complaints of alleged discrimination made to him in connection with obligations under the Contract, attempt to resolve such complaints, and take appropriate corrective action. If the investigation indicates that the discrimination may affect persons other than the complainant, corrective action shall include those persons. Upon completion of each investigation, the Contractor shall inform every complainant of all avenues of appeal.

(f) **Training:**

1. The Contractor shall assist in locating, qualifying, and increasing the skills of minority group and women employees and applicants for employment.
2. Consistent with work force requirements and as permissible under federal and state regulations, the Contractor shall make full use of training programs, i.e., apprenticeship and on-the-job training programs for the geographical area of contract performance. Where feasible, 25 percent of apprentices or trainees in each occupation shall be in their first year of apprenticeship or training.
3. The Contractor shall advise employees and applicants for employment of available training programs and the entrance requirements for each.
4. The Contractor shall periodically review the training and promotion potential of minority group employees and shall encourage eligible employees to apply for such training and promotion.
5. If the Contract does not provide a separate pay item for trainees, the cost associated with the training specified herein shall be included in the price bid for other items in the Contract.
6. If the Contract provides a pay item for trainees, training shall be in accordance with the requirements of Section 518.

(g) **Unions:** If the Contractor relies in whole or in part on unions as a source of employees, best efforts shall be made to obtain the cooperation of such unions to increase opportunities for minority groups and women in the unions and to effect referrals by such unions of minority and women employees. Actions by the Contractor, either directly or through his Contractor's Association acting as agent, shall include the following procedures:

1. In cooperation with the unions, best efforts shall be used to develop joint training programs aimed toward qualifying more minority group members and women for membership in the unions and to increase the skills of minority group employees and women so that they may qualify for higher-paying employment.

2. Best efforts shall be used to incorporate an EEO clause into union agreements to the end that unions shall be contractually bound to refer applicants without regard to race, color, religion, sex, or national origin.
 3. Information shall be obtained concerning referral practices and policies of the labor union except that to the extent the information is within the exclusive possession of the union. If the labor union refuses to furnish the information to the Contractor, the Contractor shall so certify to the Department and shall set forth what efforts he made to obtain the information.
 4. If a union is unable to provide the Contractor with a reasonable flow of minority and women referrals within the time limit set forth in the union agreement, the Contractor shall, through his recruitment procedures, fill the employment vacancies without regard to race, color, religion, sex, or national origin, making full efforts to obtain qualified or qualifiable minority group persons and women. If union referral practice prevents the Contractor from complying with the EEO requirements, the Contractor shall immediately notify the Department.
- (h) **Subcontracting:** The Contractor shall use best efforts to use minority group subcontractors or subcontractors with meaningful minority group and female representation among their employees. Contractors shall obtain lists of MBE, DBE, and WBE construction firms from the Department. If MBE, DBE, or WBE goals are established in the proposal, the Contractor shall comply with the requirements of Section 107.15.

The Contractor shall use best efforts to ensure subcontractor compliance with his EEO obligations.

- (i) **Records and Reports:** The Contractor shall keep such records as are necessary to determine compliance with his EEO obligations. The records shall be designed to indicate the following:
1. the number of minority and nonminority group members and females employed in each work classification on the project
 2. the progress and efforts being made in cooperation with unions to increase employment opportunities for minorities and females if unions are used as a source of the work force
 3. the progress and efforts being made in locating, hiring, training, qualifying, and upgrading minority and female employees
 4. the progress and efforts being made in securing the services of minority group subcontractors or subcontractors with meaningful minority group and female representation among their employees

Records shall be retained for a period of three years following completion of the contract work and shall be available at reasonable times and places for inspection by authorized representatives of the Department.

Each month for the first three months after construction begins and every month of July thereafter for the duration of the project, Form C-57 shall be completed to indicate the num-

ber of minority, nonminority, and female employees currently engaged in each work classification shown on the form. The completed Form C-57 shall be submitted within three weeks after the reporting period. Failure to do so may result in delay of approval of the Contractor's monthly progress estimate for payment.

107.15—Use of Minority Business Enterprises (MBEs)

It is the policy of the Department that Minority Business Enterprises (MBEs) shall have the maximum opportunity to participate in the performance of the Contract. The Contractor is encouraged to take necessary and reasonable steps to ensure that MBEs have the maximum opportunity to compete for and perform work on the Contract, including participation in any subsequent subcontracts.

MBE shall mean a small business concern (as defined pursuant to Section 3 of the Small Business Act and implementing regulations) that is owned and controlled by one or more minorities or women. *Owned and controlled* means: at least 51 percent of the business is owned by one or more minorities or women or, in the case of a publicly owned business, at least 51 percent of the stock is owned by one or more minorities or women; and the management and daily business operations are controlled by one or more such individuals.

Minority shall mean a person who is a citizen or lawful permanent resident of the United States and is a bona fide member of a minority group, so regarded by that particular minority community, and who is:

- Black (a person having origins in any of the black racial groups of Africa) or;
- Hispanic (a person of Mexican, Puerto Rican, Cuban, Central or South American, or other Spanish culture or origin, regardless of race) or;
- Portuguese (a person of Portuguese, Brazilian, or other Portuguese culture or origin, regardless of race) or;
- Asian American (a person having origins in any of the original peoples of the Far East, Southeast Asia, the Indian subcontinent, or the Pacific Islands) or;
- American Indian or Alaskan Native (a person having origins in any of the original peoples of North America); or
- a member of another group, or other individual, found to be economically and socially disadvantaged by the Small Business Administration under 8(a) of the Small Business Act as amended (15 U.S.C. 637[a]).

The Department will furnish, upon request, a list of certified MBEs. This list shall not be construed as an endorsement of the quality or performance of the business, but is simply a listing of firms who are certified by the Department as being MBEs.

The Contractor is encouraged to use the services of banks owned or controlled by minorities or females; however, use of such services will not be credited toward participation achievement for the Contract. The Department has on file, and will make available on request, the names and addresses of known minority and female owned banks in the Commonwealth of Virginia.

The Contractor shall designate and make known to the Department a liaison officer who is assigned the responsibility of actively and effectively administering, encouraging and promoting a responsive program for the use of MBEs.

The performance of the Contract for the purpose of this specification shall be interpreted to include, but not necessarily be limited to, subcontracting; furnishing materials, supplies, and services; and, leasing equipment.

If the Contractor intends to sublet a portion of the work on the project, the Contractor is encouraged to seek out and consider MBEs as potential subcontractors. The Contractor is encouraged to contact MBEs to solicit their interest, capability, and prices and shall retain on file the proper documentation to substantiate such contacts.

By signing the bid, the bidder certifies to the following:

- That on the work proposed to be sublet and shown on the form for *Contractors Proposal to Sublet*, the bidder has taken reasonable steps to seek out and consider MBEs as potential subcontractors.
- That, if awarded the project, any work proposed to be sublet and not shown on the form for *Contractors Proposal to Sublet*, the same reasonable steps certified herein will be taken.

If the Department has determined that specific opportunities for participation by MBEs are available on a particular Contract, such participation will be shown as a percentage of the Contract amount and will be indicated in the proposal on Form C-61, *Potential MBE Participation*.

If the bidder is an MBE that is owned and controlled by a minority female(s), participation achievement may be shown as either minority or female, but not both. Further, each bidder shall comply with the requirements of Section 102.01.

If the apparent low bidder is a currently certified MBE firm, the MBE requirements of this provision will not be applicable except for those referring to the reporting of participation achievement.

The following are examples of efforts the Department encourages Contractors to make in soliciting MBE participation. Other factors or types of efforts may be relevant in appropriate cases. The Contractor is encouraged to:

- (a) attend any pre-solicitation or pre-bid meetings at which MBEs could be informed of contracting and subcontracting opportunities;
- (b) advertise in general circulation, trade association and minority-focus media concerning the subcontracting opportunities;
- (c) provide written notice to a reasonable number of specific MBEs that their interest in the Contract was being solicited in sufficient time to allow the MBEs to participate effectively;
- (d) follow-up initial solicitations of interest by contacting MBEs to determine with certainty whether the MBEs were interested;

- (e) select portions of the work to be performed by MBEs in order to increase the likelihood of obtaining MBE participation (including, where appropriate, breaking down contracts into economically feasible units to facilitate MBE participation);
- (f) provide interested MBEs with adequate information about the plans, Specifications, and requirements of the Contract;
- (g) negotiate in good faith with interested MBEs, not rejecting MBEs as unqualified without sound reasons based on a thorough investigation of their capabilities;
- (h) make efforts to assist interested MBEs in obtaining bonding, lines of credit, or insurance required by the Department or Contractor;
- (i) make efforts to assist interested MBEs in obtaining necessary equipment, supplies, materials, or other necessary or related assistance or services; and,
- (j) effectively use the services of available minority community organizations; minority contractors' groups; local, state and federal minority business assistance offices; and other organizations that provide assistance in the recruitment and placement of MBEs.

Any agreement between a bidder and an MBE whereby the MBE agrees not to provide quotations for performance of work to other bidders is prohibited.

Within 14 days after the opening of proposals in accordance with Section 102.12, if the apparent low bidder, as read at the bid opening, is reporting participation achievement on the Contract, he shall submit to the Department a fully executed Form C-61 showing the name(s) and certification number(s) of any currently certified MBEs who will perform work eligible to be reported as said participation credit.

The signatures on Form C-61 shall be those of authorized representatives of the bidder as shown on Forms C-37 and C-38A or as authorized by letter from the bidder.

If it is determined, subsequent to the bid opening, that the apparent low bidder as read at the bid opening has changed, the new apparent low bidder will be advised by letter and shall submit the information required herein within 14 days after the date of notification.

Any award made by the Board prior to receipt of the information required will be conditional, pending receipt of such information.

The Contractor shall furnish, and require each subcontractor to furnish, prior to final acceptance of the Contract, information relative to all MBE involvement on the project if such work is to be claimed as participation achievement and verification is available. The information shall be indicated on Form C-63, *MBE/DBE/SWAM Payment Compliance Report* or by copies of canceled checks with appropriate identifying notations. If participation achievement is with an MBE whose name has not been previously furnished, an initial or revised Form C-61, whichever is appropriate, shall be submitted prior to such MBE beginning the work. Failure to provide the Department the forms by the Contractor's semi-final estimate may result in delay of approval of the Contractor's estimate for payment.

If an MBE, through no fault of the Contractor, is unable or unwilling to fulfill his agreement with the Contractor, the Contractor shall immediately notify the Department and provide all relevant facts. If any subcontractor is relieved of the responsibility to perform work under their subcontract, the Con-

tractor is encouraged to take steps to obtain an MBE to perform an equal or greater dollar value of the work. The substitute MBE's name, description of the work, and dollar value of the work shall be submitted to the Department on Form C-61 prior to such MBE beginning the work, if such work is to be counted for participation achievement.

107.16—Environmental Stipulations

By signing the bid, the bidder shall have stipulated (1) that any facility to be used in the performance of the Contract (unless the Contract is exempt under the Clean Air Act as amended [42 U.S.C. 1857, et seq., as amended by P.L. 91-604], the Federal Water Pollution Control Act as amended [33 U.S.C. 1251 et seq. as amended by P.L. 92-500], and Executive Order 11738 and regulations in implementation thereof [40 C.F.R., Part 15]) is not listed on the EPA's List of Violating Facilities pursuant to 40 C.F.R. 15.20; and (2) that the Department will be promptly notified prior to the award of the Contract if the bidder receives any communication from the Director, Office of Federal Activities, EPA, indicating that a facility to be used for the Contract is under consideration to be listed on the EPA's List of Violating Facilities.

No separate payment will be made for the work or precautions described herein except where provided for as a specific item in the Contract or except where provision has been made for such payment in these Specifications.

Reference is made in various subsections of this section to Tidewater, Virginia. For the purposes of identifying the affected regions assigned to this designation and the requirements therein Tidewater, Virginia is defined as the Counties of Accomack, Arlington, Caroline, Charles City, Chesterfield, Essex, Fairfax, Gloucester, Hanover, Henrico, Isle of Wight, James City, King George, King and Queen, King William, Lancaster, Mathews, Middlesex, New Kent, Northampton, Northumberland, Prince George, Prince William, Richmond, Spotsylvania, Stafford, Surry, Westmoreland and York and the Cities of Alexandria, Chesapeake, Colonial Heights, Fairfax, Falls Church, Fredericksburg, Hampton, Hopewell, Newport News, Norfolk, Petersburg, Poquoson, Portsmouth, Richmond, Suffolk, Virginia Beach and Williamsburg.

- (a) **Erosion and Siltation:** The Contractor shall exercise every reasonable precaution, including temporary and permanent soil stabilization measures, throughout the duration of the project to control erosion and prevent siltation of adjacent lands, rivers, streams, wetlands, lakes, and impoundments. Soil stabilization and/or erosion control measures shall be applied to erodible soil or ground materials exposed by any activity associated with construction, including clearing, grubbing, and grading, but not limited to local or on-site sources of materials, stockpiles, disposal areas and haul roads.

The Contractor shall comply with the requirements of Sections 301.02 and 303.03. Should the Contractor as a result of negligence or noncompliance leave an area exposed more than 15 days, the cost of temporary soil stabilization in accordance with the provisions of Section 303 shall be at the Contractor's expense. If the delay in stabilizing an exposed area of land is due to circumstances beyond the Contractor's control, the Department will be responsible for the expense.

Temporary measures shall be coordinated with the work to ensure effective and continuous erosion and sediment control. Permanent erosion control measures and drainage facilities shall be installed as the work progresses.

For projects that disturb 10,000 square feet or greater of land or 2,500 square feet or greater in Tidewater, Virginia, the Contractor shall have within the limits of the project during land disturbance activities, an employee certified by the Department in Erosion and Sediment control who shall inspect erosion and siltation control devices and measures for proper installation and operation immediately after each rainfall, at least daily during periods of prolonged rainfall, and weekly when no rainfall event occurs and promptly report their findings to the Inspector. Failure of the Contractor to maintain a certified employee within the limits of the project will result in the Engineer suspending work related to any land disturbing activity until such time as a certified employee is present on the project. Failure on the part of the Contractor to maintain appropriate erosion and siltation control devices in a functioning condition may result in the Engineer notifying the Contractor in writing of specific deficiencies. Deficiencies shall be corrected immediately. If the Contractor fails to correct or take appropriate actions to correct the specified deficiencies within 24 hours after receipt of such notification, the Department may do one or more of the following: require the Contractor to suspend work in other areas and concentrate efforts towards correcting the specified deficiencies, withhold payment of monthly progress estimates, or proceed to correct the specified deficiencies and deduct the entire cost of such work from monies due the Contractor. Failure on the part of the Contractor to maintain a Department certified erosion and sediment control employee within the project limits when land disturbance activities are being performed will result in the Engineer suspending work related to any land disturbance activity until such time as the Contractor is in compliance with this requirement.

(b) **Pollution:**

1. **Water:** The Contractor shall exercise every reasonable precaution throughout the duration of the project to prevent pollution of rivers, streams, and impoundments. Pollutants such as, but not limited to, chemicals, fuels, lubricants, bitumens, raw sewage, paints, sedimentation, and other harmful material shall not be discharged into or alongside rivers, streams, or impoundments or into channels leading to them. The Contractor shall provide the Engineer a contingency plan for reporting and immediate actions to be taken in the event of a dump, discharge, or spill within eight hours after he has mobilized to the project site.

Construction discharge water shall be filtered to remove deleterious materials prior to discharge into state waters. Filtering shall be accomplished by the use of a standard dewatering basin or a dewatering bag. Dewatering bags shall conform to the requirements of Section 245. During specified spawning seasons, discharges and construction activities in spawning areas of state waters shall be restricted so as not to disturb or inhibit aquatic species that are indigenous to the waters. Neither water nor other effluence shall be discharged onto wetlands or breeding or nesting areas of migratory waterfowl. When used extensively in wetlands, heavy equipment shall be placed on mats. Temporary construction fills and mats in wetlands and flood plains shall be constructed of approved nonerodible materials and shall be removed by the Contractor to natural ground when the Engineer so directs.

If the Contractor dumps, discharges, or spills any oil or chemical that reaches or has the potential to reach a waterway, he shall immediately notify all appropriate jurisdictional state and federal agencies in accordance with the requirements of Section 107.01 and shall take immediate actions to contain, remove, and properly dispose of the oil or chemical.

Excavation material shall be disposed of in approved areas above the mean high water mark shown on the plans in a manner that will prevent the return of solid or suspended materials to state waters. If the mark is not shown on the plans, the mean high water mark shall be considered the elevation of the top of stream banks.

Constructing new bridge(s) and dismantling and removing existing bridge(s) shall be accomplished in a manner that will prevent the dumping or discharge of construction or disposable materials into rivers, streams, or impoundments.

Construction operations in rivers, streams, or impoundments shall be restricted to those areas where identified on the plans and to those that must be entered for the construction of structures. Rivers, streams, and impoundments shall be cleared of falsework, piling, debris, or other obstructions placed therein or caused by construction operations. Stabilization of the streambed and banks shall occur immediately upon completion of work if work is suspended for more than 15 days.

The Contractor shall prevent stream constriction that would reduce stream flows below the minimum, as defined by the State Water Control Board, during construction operations.

If it is necessary to relocate an existing stream or drainage facility temporarily to facilitate construction, the Contractor shall design and provide temporary channels or culverts of adequate size to carry the normal flow of the stream or drainage facility. The Contractor shall submit a temporary relocation design to the Engineer for review and acceptance in sufficient time to allow for discussion and correction prior to beginning the work the design covers. Costs for the temporary relocation of the stream or drainage facility shall be included in the Contract price for the related pipe or box culvert, unless specifically provided for under another Pay Item. Stabilization of the streambed and banks shall occur immediately upon completion of, or during the work or if the work is suspended for more than 15 days.

Temporary bridges or other minimally invasive structures shall be used wherever the Contractor finds it necessary to cross a stream more than twice in a 6 month period, unless otherwise authorized by water quality permits issued by the U. S. Army Corps of Engineers, Virginia Marine Resources Commission or the Virginia Department of Environmental Quality for the Contract.

2. **Air:** The Contractor shall comply with the provisions of Section 107.01 and the State Air Pollution Control Law and Rules of the State Air Pollution Control Board, including notifications required therein.

Burning shall be performed in accordance with all applicable local laws and ordinances and under the constant surveillance of watchpersons. Care shall be taken so that the burning of materials does not destroy or damage property or cause excessive air pollution. The Contractor shall not burn rubber tires, asphalt, used crankcase oil, or other materials that produce dense smoke. Burning shall not be initiated when atmospheric conditions are such that smoke will create a hazard to the motoring public or airport operations. Provisions shall be made for flagging vehicular traffic if visibility is obstructed or impaired by smoke. At no time shall a fire be left unattended.

Asphalt mixing plants shall be designed, equipped, and operated so that the amount and quality of air pollutants emitted will conform to the rules of the State Air Pollution Control Board.

Emission standards for asbestos incorporated in the EPA's National Emission Standards for Hazardous Air Pollutants apply to the demolition or renovation of any institutional, commercial, or industrial building, structure, facility, installation, or portion thereof that contains friable asbestos or where the Contractor's methods for such actions will produce friable asbestos.

3. **Noise:** The Contractor's operations shall be performed so that exterior noise levels measured during a noise-sensitive activity shall not exceed 80 decibels. Such noise level measurements shall be taken at a point on the perimeter of the construction limit that is closest to the adjoining property on which a noise sensitive activity is occurring. A *noise-sensitive activity* is any activity for which lowered noise levels are essential if the activity is to serve its intended purpose and not present an unreasonable public nuisance. Such activities include, but are not limited to, those associated with residences, hospitals, nursing homes, churches, schools, libraries, parks, and recreational areas.

The Department may monitor construction-related noise. If construction noise levels exceed 80 decibels during noise sensitive activities, the Contractor shall take corrective action before proceeding with operations. The Contractor shall be responsible for costs associated with the abatement of construction noise and the delay of operations attributable to noncompliance with these requirements.

The Department may prohibit or restrict to certain portions of the project any work that produces objectionable noise between 10 P.M. and 6 A.M. If other hours are established by local ordinance, the local ordinance shall govern.

Equipment shall in no way be altered so as to result in noise levels that are greater than those produced by the original equipment.

When feasible, the Contractor shall establish haul routes that direct his vehicles away from developed areas and ensure that noise from hauling operations is kept to a minimum.

These requirements shall not be applicable if the noise produced by sources other than the Contractor's operation at the point of reception is greater than the noise from the Contractor's operation at the same point.

- (c) **Forests:** The Contractor shall take all reasonable precautions to prevent and suppress forest fires in any area involved in construction operations or occupied by him as a result of such operations. The Contractor shall cooperate with the proper authorities of the state and federal governments in reporting, preventing, and suppressing forest fires. Labor, tools, or equipment furnished by the Contractor upon the order of any forest official issued under authority granted the official by law shall not be considered a part of the Contract. The Contractor shall negotiate with the proper forest official for compensation for such labor, tools, or equipment
- (d) **Archeological, Paleontological, and Rare Mineralogical Findings:** In the event of the discovery of prehistoric ruins, Indian or early settler sites, burial grounds, relics, fossils, me-

teorites, or other articles of archeological, paleontological, or rare mineralogical interest during the prosecution of work, the Contractor shall act immediately to suspend work at the site of the discovery and notify the Engineer. The Engineer will immediately notify the proper state authority charged with the responsibility of investigating and evaluating such finds. The Contractor shall cooperate and, upon the request of the Engineer, assist in protecting, mapping, and removing the findings. Labor, tools, or equipment furnished by the Contractor for such work will be paid for in accordance with the requirements of Section 104.03. Findings shall become the property of the Commonwealth unless they are located on federal lands, in which event they shall become the property of the U.S. government.

When such findings delay the progress or performance of the work, the Contractor shall notify the Engineer in accordance with the provisions of Sections 108.03 and Section 109.05.

(e) **Storm Water Pollution Prevention Plan**

The Storm Water Pollution Prevention Plan (SWPPP) is comprised of, but not limited to, the Erosion and Sediment Control (ESC) Plan, the Stormwater Management (SWM) Plan and related Specifications and Standards contained within all contract documents and shall be required for all land-disturbing activities that disturb 10,000 square feet or greater, or 2,500 square feet or greater in Tidewater, Virginia.

For land-disturbing activities that disturb 1 acre or greater, or 2500 square feet or greater in an area designated as a Chesapeake Bay Preservation Area, coverage under the Department of Conservation and Recreation's Virginia Stormwater Management Program (VSMP) General Construction Permit DCR-01 is required. Where applicable, the Department will apply for and retain coverage under this permit for the land disturbing activity. The requirements of this permit will be satisfied by the Contractor's compliance with the project's SWPPP terms and conditions.

The Contractor shall be responsible for reading, understanding, and complying with the terms and conditions of the DCR-01 General Permit and the project's SWPPP as follows:

1. **Project Implementation Responsibilities**

The Contractor shall be responsible for the installation, maintenance, inspection, and ensuring the functionality of all erosion and sediment control measures on a daily basis and all other stormwater and pollutant runoff control measures identified within or referenced within the plans, Specifications, permits, and other contract documents.

The Contractor shall take all reasonable steps to prevent or minimize any stormwater or non-stormwater discharge that will have a reasonable likelihood of adversely affecting human health or public and/or private properties.

2. **Certification Requirements**

In addition to satisfying the personnel certification requirements contained herein, the Contractor shall certify his activities by completing, signing, and submitting Form C-45 VDOT SWPPP Contractor and Subcontractor Certification Statement to the Engineer at least 7 days prior to commencing any project related land-disturbing activities, both on-site and off-site.

3. **Off Site (Outside the Construction Limits) Requirements**

The Contractor shall develop erosion and sediment control plan(s) and stormwater pollution prevention plan(s) for submission and acceptance by the Engineer prior to usage of any support facilities, off-site borrow and disposal areas, construction materials or equipment storage areas, and any other areas that may generate a stormwater or non-stormwater discharge directly related to the construction process. Such plans, upon acceptance, shall become a part of and subject to the overall project plan, the VSMP General Construction Permit, and all other contract requirements.

4. **Reporting Procedures**

a. **Inspection Requirements**

The Contractor shall be responsible for conducting inspections in accordance with the requirements herein. The Contractor shall document such inspections by completion of Form C-107 (a) and (b), Construction Runoff Control Inspection Form and Continuation Sheet, in strict accordance with the directions contained within the form.

b. **Unauthorized Discharge Requirements**

The Contractor shall not discharge into state waters sewage, industrial wastes, other wastes or any noxious or deleterious substances nor shall otherwise alter the physical, chemical, or biological properties of such waters that render such waters detrimental for or to domestic use, industrial consumption, recreational or other public uses.

(1) **Notification of non-compliant discharges**

The Contractor shall immediately notify the Engineer upon the discovery of or potential of any unauthorized, unusual, extraordinary, or non-compliant discharge from the land disturbing activity. Where immediate notification is not possible, such notification shall be not later than 24 hours after said discovery.

(2) **Detailed report requirements for non-compliant discharges**

The Contractor shall submit to the Engineer within 5 days of the discovery of any actual or potential non-compliant discharge a written report describing details of the discharge to include its volume, location, cause, and any apparent or potential effects on private and/or public properties and state waters or endangerment to public health, as well as steps being taken to eliminate the discharge. A completed Form C-107 (a) and (b) shall be used for such reports.

5. **Plans, Changes, Deficiencies and Revisions**

a. **Contractor SWPPP**

The Contractor shall develop and provide a SWPPP that documents the location and description of potential pollutant sources such as vehicle fueling areas, storage areas for fertilizers or chemicals, sanitary waste facilities, construction and waste material storage areas, etc. prior to any such pollutant sources being established on the project site. Such plans and documentation shall include a description of the controls to reduce, prevent and control pollutants from these sources including spill prevention and response. The Contractor shall submit such plans and documentation as specified herein to the Engineer and, upon review and approval, they shall immediately become a component of the project's SWPPP and subject to all corresponding requirements contained therein.

The Contractor shall ensure that the SWPPP is kept on the project site at all times in accordance with the provisions of Section 105.10 and shall be available for review upon request.

b. Changes and Deficiencies

The Contractor shall report to the Engineer when any planned physical alterations or additions are made to the land disturbing activity or deficiencies in the project plans or contract documents are discovered that could significantly change the nature or increase the quantity of the pollutants discharged from the land disturbing activity to surface waters.

c. Revisions to the SWPPP

Where site conditions or construction sequencing or scheduling necessitates revisions or modifications to the erosion and sediment control plan or other any other component of the SWPPP for the land disturbing activity, such revisions or modifications shall be approved by the Engineer and shall be documented by the Contractor on a designated plan set (Record Set). Such plans shall be kept on the project site at all times and shall be available for review upon request.

107.17—Construction Safety and Health Standards

Compliance with construction safety and health standards is a condition of the Contract, and shall be made a condition of each subcontract entered into pursuant to the Contract, that the Contractor and any subcontractor shall not require any worker employed in performance of the Contract to work in surroundings or under working conditions that are unsanitary, hazardous, or dangerous to their health or safety, as determined under construction safety and health standards promulgated by the U.S. Secretary of Labor in accordance with the requirements of Section 107 of the Contract Work Hours and Safety Standards Act.

The Contractor shall comply with the Virginia Occupational Safety and Health Standards adopted under the *Code of Virginia* and the duties imposed under the Code. Any violation of the requirements or duties that is brought to the attention of the Contractor by the Engineer or any other person shall be immediately abated.

At a minimum, all Contractor personnel shall comply with the following, unless otherwise determined unsafe or inappropriate in accordance with OSHA regulations:

1. Hard hats shall be worn while participating in or observing all types of field work when outside of a building or outside of the cab of a vehicle, and exposed to, participating in or supervising construction.
2. Respiratory protective equipment shall be worn whenever an individual is exposed to any item listed in the OSHA Standards as needing such protection unless it is shown that the employee is protected by engineering controls.
3. Adequate eye protection shall be worn in the proximity of grinding, breaking of rock and/or concrete, while using brush chippers, striking metal against metal or when working in situations where the eyesight may be in jeopardy.
4. A safety vest shall be worn by all exposed to vehicular traffic and construction equipment.
5. Standards and guidelines of the current Virginia Work Area Protection Manual shall be used when setting, reviewing, maintaining, and removing traffic controls.
6. Flaggers shall be certified in accordance with the Virginia Flagger Certification Program.
7. No person shall be permitted to position themselves under any raised load or between hinge points of equipment without first taking steps to support the load by the placing of a safety bar or blocking.
8. Explosives shall be purchased, transported, stored, used and disposed of by a Virginia State Certified Blaster in possession of a current criminal history record check and a commercial driver's license with hazardous materials endorsement and a valid medical examiner's certificate. All Federal, State and local regulations pertaining to explosives shall be strictly followed.
9. All electrical tools shall be adequately grounded or double insulated. Ground Fault Circuit Interrupter (GFCI) protection must be installed in accordance with the National Electrical Code (NEC) and current Virginia Occupational Safety and Health agency (VOSH). If extension cords are used, they shall be free of defects and designed for their environment and intended use.
10. No person shall enter a confined space without training, permits and authorization.
11. Fall protection shall be required whenever an employee is exposed to a fall six feet or greater.

107.18—Sanitary Provisions

The Contractor shall provide and maintain in a neat, sanitary condition such accommodations for the use of employees as may be necessary to comply with the requirements of the state and local Board of Health or other bodies or tribunals having jurisdiction.

107.19—Railway-Highway Provisions

If the Contractor's work requires hauling materials across the tracks of a railway, he shall make arrangements with the railway for any new crossing(s) required. Access to existing rail crossings with off-road heavy equipment shall also be arranged by the Contractor. Charges made by the railway company for the construction or use of new or existing crossings and their subsequent removal and for watchperson or flagger service at such crossings shall be reimbursed by the Contractor directly to the railway company under the terms of their separate individual arrangements before final acceptance.

Work to be performed by the Contractor in construction on or over the railway right of way shall be performed at times and in a manner that will not unnecessarily interfere with the movement of trains or traffic on the railway track. The Contractor shall use care to avoid accidents, damage, or unnecessary delay or interference with the railway company's trains or other property. If any interruption of railway traffic is required by the Contractor's actions, he shall obtain prior written approval from the railway company.

The Contractor shall conduct operations that occur on or over the right of way of any railway company fully within the rules, regulations, and requirements of the railway company and in accordance with the requirements of any agreements made between the Department and the railway company that are a part of the Contract. Said agreements are included within the Contract Documents.

- (a) **Flagger or Watchperson Services:** Flagger or watchperson services required by the railway company for the safety of railroad operations because of work being performed by the Contractor or incidental thereto will be provided by the railway company. The cost for such services as required for work shown on the plans will be borne by the Department. Any cost of such services resulting from work not shown on the plans or for the Contractor's convenience shall be borne by the Contractor and shall be paid directly to the railway company(s) under the terms of their separate individual agreement.

No work shall be undertaken on or over the railway right of way until the watchpersons or flaggers are present at the project site. The Contractor shall continuously prosecute the affected work to completion to minimize the need for flagger or watchperson services. Costs for such services that the Engineer determines to be unnecessary because of the Contractor's failure to give notice as required herein before initially starting, intermittently continuing, or discontinuing work on or over the railway right of way shall be borne by the Contractor and will be deducted from monies due him.

- (b) **Approval of Construction Methods on Railway Right of Way:** The Contractor shall submit to the Department a plan of operations showing the design and method of proposed structural operations and shall obtain its approval before performing any work on the railway company's right of way unless otherwise indicated in the railroad agreement. The plan shall be clear and legible, and details shall be drawn to scale. The plan shall incorporate any stipulations or requirements the railroad may impose for the evaluation of the Contractor's contemplated operations. The plan shall show, but not be limited to, the following:

1. proximity of construction operations to tracks
2. depth of excavation with respect to tracks
3. description of structural units

4. vertical and horizontal clearances to be afforded the railroad during installation and upon completion of excavation
5. sheeting and bracing
6. method and sequence of operations

Approval shall not relieve the Contractor of any liability under the Contract. The Contractor shall arrange the work so as not to interfere with the railway company's operation except by agreement with the railway company.

- (c) **Insurance:** In addition to insurance or bonds required under the terms of the Contract, the Contractor shall carry insurance covering operations affecting the property of the railway company. The original railroad protective liability insurance policy and certificate of insurance showing insurance carried by the Contractor and any subcontractors shall be submitted to the railway company for approval and retention.

Neither the Contractor nor any subcontractor shall begin any work affecting the railway company until the railway company has received the insurance.

Notice of any material change in or cancellation of the required policies shall be furnished the Department and the railway company at least 30 days prior to the effective date of the change or cancellation. The insurance shall be of the following kinds and amounts:

1. **Contractor's public liability and property damage insurance:** The Contractor shall furnish evidence to the Department with respect to the operations to be performed that he carries regular contractor's public liability insurance. The insurance shall provide for a limit of at least the dollar value specified in the Contract for all damages arising out of bodily injuries to or the death of one person, and subject to that limit for each person, a total limit of at least the dollar value specified in the Contract for all damages arising out of bodily injuries to or death of two or more persons in any one occurrence, and regular contractor's property damage insurance providing for a limit of at least the dollar value specified in the Contract for all damages arising out of bodily injury to or destruction of property in any one occurrence, and subject to that limit per occurrence, a total or aggregate limit of at least the dollar value specified in the Contract for all damages arising out of injury to or destruction of property during the policy period. The Contractor's public liability and property damage insurance shall include explosion, collapse, and underground damage coverage. If the Contractor subcontracts any portion of the work, he shall secure insurance protection in his own behalf under the Contract's public liability and property damage insurance policies to cover any liability imposed on him by law for damages because of bodily injury to, or death of persons and injury to, or destruction of property as a result of work undertaken by the subcontractors. In addition, the Contractor shall provide similar insurance protection for and on behalf of any subcontractors to cover their operation by means of separate and individual contractor's public liability and property damage policies. As an alternative, he shall require each subcontractor to provide such insurance in his own behalf.
2. **Railroad protective insurance and public liability and property damage:** The policy furnished the railway company shall include coverage for contamination, pollution, explosion, collapse, and underground damage. The policy shall be of the type specified hereinafter and shall be expressed in standard language that may not be amended. No

part shall be omitted except as indicated hereinafter or by an endorsement that states an amendment or exclusion of some provision of the form in accordance with the provisions of a manual rule. The form of the endorsement shall be approved as may be required by the supervising authority of the state in which the policy is issued. A facsimile of the Policy Declarations form as shown in the proposal shall be made a part of the policy and shall be executed by an officer of the insurance company. The several parts of the requirements and stipulations specified or inferred herein may appear in the policy in such sequence as the company may elect.

a. **For a policy issued by one company:**

(NAME AND LOCATION OF INDEMNITY COMPANY), a _____

(Type of Company)

Insurance Company, herein called the Company, agrees with the insured named in the Policy Declarations made a part hereof, in consideration of the payment of the premium and in reliance upon the statements in the Policy Declarations made by the named insured and subject to all of the terms of his policy.

For a policy issued by two companies:

(NAME AND LOCATION OF INDEMNITY COMPANY) and

(NAME AND LOCATION OF INDEMNITY COMPANY),

each a _____ Insurance Company, herein called the Company,

(Type of Company)

severally agree with the insured named in the Policy Declarations made a part hereof, in consideration of the payment of the premium and in reliance upon the statements in the Policy Declaration made by the named insured and subject to all of the terms of this policy, provided the named Indemnity Company shall be the insured with respect to Coverage _____ and no other and the named Insurance Company shall be the insurer with respect to Coverage _____ and no other.

b. **Insuring agreements:**

(1) **Coverages: Coverage A—Bodily injury liability:** To pay on behalf of the insured all sums that the insured shall become legally obligated to pay as damages because of bodily injury, sickness, or disease including death at any time resulting therefrom (hereinafter called bodily injury) either (1) sustained by any person arising out of acts or omissions at the designated job site that are related to or are in connection with the work described in Item 6 of the Policy Declarations; or (2) sustained at the designated job site by the Contractor, any employee of the Contractor, any employee of the governmental authority specified in Item 5 of the Policy Declarations, or any designated employee of the insured, whether or not arising out of such acts or omissions.

Coverage B—Property damage liability: To pay on behalf of the insured all sums the insured shall become legally obligated to pay as damages because of physical injury to or destruction of property, including loss of use of any property because of such injury or destruction (hereinafter called property damage) arising out of acts or omissions at the designated job site that are

related to or are in connection with the work described in Item 6 of the Policy Declarations.

Coverage C—Physical damage to property: To pay for direct and accidental loss of or damage to rolling stock and other contents, mechanical construction equipment, or motive power equipment (hereinafter called loss) arising out of acts or omissions at the designated job site that are related to or are in connection with the work described in Item 6 of the Policy Declarations; provided such property is owned by the named insured or is leased or entrusted to the named insured under a lease or trust agreement.

- (2) **Definitions:** *Insured* means and includes the named insured and any executive officer, director, or stockholder thereof while acting within the scope of his duties as such.

Contractor means the Contractor designated in Item 4 of the Policy Declarations and includes all subcontractors of the Contractor but not the named insured.

Designated employee of the insured means (1) any supervisory employee of the insured at the job site; (2) any employee of the insured while operating, attached to, or engaged on work trains or other railroad equipment at the job site that is assigned exclusively to the Contractor; or (3) any employee of the insured not within (1) or (2) who is specifically loaned or assigned to the work of the Contractor for prevention of accidents or protection of property, the cost of whose services is borne specifically by the Contractor or governmental authority.

Contract means any contract or agreement to carry a person or property for a consideration or any lease, trust, or interchange contract or agreement respecting motive power, rolling stock, or mechanical construction equipment.

- (3) **Defense and settlement supplementary payments:** With respect to such insurance as is afforded by this policy under Coverages A and B, the Company shall defend any suit against the insured alleging such bodily injury or property damage and seeking damages that are payable under the terms of this policy, even if any of the allegations of the suit are groundless, false, or fraudulent. However, the Company may make such investigation and settlement of any claim or suit as it deems expedient.

In addition to the applicable limits of liability, the Company shall pay (1) all expenses incurred by the company, all costs taxed against the insured in any such suit, and all interest on the entire amount of any judgment therein that accrues after entry of the judgment and before the Company has paid or tendered or deposited in court that part of the judgment that does not exceed the limit of the Company's liability thereon; (2) premiums on appeal bonds required in any such suit and premiums on bonds to release attachments for an amount not in excess of the applicable limit of liability of this policy, but without obligation to apply for or furnish any such bonds; (3) expenses incurred by the insured for first aid to others that shall be imperative at the

time of the occurrence; and (4) all reasonable expenses, other than loss of earnings, incurred by the insured at the Company's request.

- (4) **Policy period and territory:** This policy applies only to occurrences and losses during the policy period and within the United States, its territories or possessions, or Canada.
- c. **Exclusions:** This policy does not apply to the following:
- (1) liability assumed by the insured under any contract or agreement except a contract as defined herein
 - (2) bodily injury or property damage caused intentionally by or at the direction of the insured
 - (3) bodily injury, property damage, or loss that occurs after notification to the named insured of the acceptance of the work by the governmental authority, other than bodily injury, property damage, or loss resulting from the existence or removal of tools, uninstalled equipment, and abandoned or unused materials
 - (4) under Coverage A(1), B, and C, to bodily injury, property damage, or loss, the sole proximate cause of which is an act or omission of any insured
 - (5) under Coverage A, to any obligation for which the insured or any carrier as his insurer may be held liable under any workers' compensation, employment compensation, or disability benefits law or under any similar law; provided that the Federal Employer's Liability Act, *U.S. Code* (1946) Title 45, Sections 51-60, as amended, shall for the purpose of this insurance be deemed not to be any similar law
 - (6) under Coverage B, to injury to or destruction of property owned by the named insured or leased or entrusted to the named insured under a lease or trust agreement
 - (7) under any liability coverage, to injury, sickness, disease, death, or destruction (1) with respect to which an insured under the policy is also an insured under a nuclear energy liability policy issued by the Nuclear Energy Liability Insurance Association, Mutual Atomic Energy Liability Underwriters, or Nuclear Insurance Association of Canada or would be an insured under any such policy but for its termination upon exhaustion of its limit of liability; or (2) resulting from the hazardous properties of nuclear material and with respect to which any person or organization is required to maintain financial protection pursuant to the Atomic Energy Act of 1954 or any law amendatory thereof or the insured is (or had this policy not been issued would be) entitled to indemnity from the United States or any agency thereof under any agreement entered into by the United States, or any agency thereof, with any person or organization
 - (8) under any Medical Payments Coverage or any Supplementary Payments provision relating to immediate medical or surgical relief or to expenses in-

curred with respect to bodily injury, sickness, disease, or death resulting from the hazardous properties of nuclear material and arising out of the operation of a nuclear facility by any person or organization

- (9) under any liability coverage, to injury, sickness, disease, death, or destruction resulting from the hazardous properties of nuclear material if (1) the nuclear material is at any nuclear facility owned or operated by or on behalf of an insured or has been discharged or dispersed therefrom; (2) the nuclear material is contained in spent fuel or waste at any time possessed, handled, used, processed, stored, transported, or disposed of by or on behalf of an insured; or (3) the injury, sickness, disease, death, or destruction arises out of the furnishing by an insured of services, materials, or parts for equipment in connection with the planning, construction, maintenance, operation, or use of any nuclear facility; if such facility is located in the United States, its territories or possessions, or Canada, this exclusion applies only to injury to or destruction of property at such nuclear facility
- (10) under Coverage C, to loss attributable to nuclear reaction, nuclear radiation, or radioactive contamination or to any act or condition incident to any of the foregoing

As used in exclusions (7), (8), and (9), the following definitions apply: *Hazardous properties* include radioactive, toxic, or explosive properties. *Nuclear material* means source material, special nuclear material, or byproduct material. *Source material, special nuclear material, and byproduct material* have the meanings given them in the Atomic Energy Act of 1954 or in any law amendatory thereof. *Spent fuel* means any fuel element or fuel component (solid or liquid) that has been used or exposed to radiation in a nuclear reaction. *Disposable material* means material containing byproduct material and resulting from the operation by any person or organization of any nuclear facility included in the definition of nuclear facility under 1 or 2 below. *Nuclear facility* means:

- (1) any nuclear reactor
- (2) any equipment or device designed or used for separating the isotopes of uranium or plutonium; processing or utilizing spent fuel; or handling, processing, or packaging waste
- (3) any equipment or device designed or used for the processing, fabricating, or alloying of special nuclear material if at any time the total amount of such material in the custody of the insured at the premises where such equipment or device is located consists of or contains more than 25 grams of plutonium or uranium 233 (or any combination thereof) or more than 250 grams of uranium 235
- (4) any structure, basin, excavation, premises, or place prepared or used for the storage or disposal of waste (includes the site on which any of the foregoing is located, all operation conducted on such site, and all premises used for such operations) *Nuclear reactor* means any apparatus designed or used to sustain nuclear fission in a self-supporting chain reaction or to contain a critical mass of fissionable material. With respect to injury to or destruction of

property, *injury* or *destruction* includes all forms of radioactive contamination of property.

- d. **Conditions:** The following conditions, except conditions (3) through (12), apply to all coverages. Conditions (3) through (12) apply only to the coverage noted thereunder.
- (1) **Premium:** The premium bases and rates for the hazards described in the Policy Declarations are stated therein. Premium bases and rates for hazards not so described are those applicable in accordance with the requirements of the manuals used by the company. The term “contract cost” means the total cost of all work described in Item 6 of the Policy Declaration. The term “rental cost” means the total cost to the Contractor for rental or work trains or other railroad equipment, including the remuneration of all employees of the insured while operating, attached to, or engaged thereon. The advance premium stated in the Policy Declarations is an estimated premium only. Upon termination of this policy, the earned premium shall be computed in accordance with the Company’s rules, rates, rating plans, premiums, and minimum premiums applicable to this insurance. If the earned premium thus computed exceeds the estimated advance premium paid, the Company shall look to the Contractor specified in the Policy Declarations for any such excess. If the earned premium is less than the estimated advance premium paid, the Company shall return to the Contractor the unearned portion paid. In no event shall payment or premium be an obligation of the named insured.
 - (2) **Inspection:** The named insured shall make available to the Company records of information relating to the subject matter of this insurance. The Company shall be permitted to inspect all operations in connection with the work described in Item 6 of the Policy Declarations.
 - (3) **Limits of liability, Coverage A:** The limit of bodily injury liability stated in the Policy Declarations as applicable to “each person” is the limit of the Company’s liability for all damages (including damages for care and loss of services) arising out of bodily injury sustained by one person as the result of any one occurrence. The limit of such liability stated in the Policy Declarations as applicable to “each occurrence” is (subject to the provision respecting each person) the total limit of the Company’s liability for all such damage arising out of bodily injury sustained by two or more persons as the result of any one occurrence.
 - (4) **Limits of liability, Coverages B and C:** The limit of liability under Coverages B and C stated in the Policy Declarations as applicable to “each occurrence” is the total limit of the Company’s liability for all damages and all loss under Coverages B and C combined arising out of physical injury to, destruction of, or loss of all property of one or more persons or organizations, including the loss or use of any property attributable to such injury or destruction under Coverage B, as the result of any one occurrence. Subject to the provision respecting “each occurrence”, the limit of liability under Coverages B and C stated in the Policy Declaration as “aggregate” is the total limit of the Company’s liability for all damages and all loss under Coverages B and C combined arising out of physical injury to, destruction of, or loss of

property, including the loss or use of any property attributable to such injury or destruction under Coverage B.

Under Coverage C, the limit of the Company's liability for loss shall not exceed the actual cash value of the property, or if the loss is a part thereof, the actual cash value of such part, at time of loss, nor what it would then cost to repair or replace the property of such part thereof with other of like kind and quality.

- (5) **Severability of interests, Coverages A and B:** The term *the insured* is used severally and not collectively. However, inclusion herein of more than one insured shall not operate to increase the limits of the Company's liability.
- (6) **Notice:** In the event of an occurrence or loss, written notice containing particulars sufficient to identify the insured and also reasonably obtainable information with respect to the time, place, and circumstances thereof and the names and addresses of the injured and of able witnesses shall be given by or for the insured to the company or any of its authorized agents as soon as is practicable. If a claim is made or a suit is brought against the insured, he shall immediately forward to the Company every demand, notice, summons, or other process received by him or his representative.
- (7) **Assistance and cooperation of the insured, Coverages A and B:** The insured shall cooperate with the Company and upon the Company's request attend hearings and trials and assist in making settlements, securing and giving evidence, obtaining the attendance of witnesses, and conducting suits. Except at his own cost, the insured shall not voluntarily make any payment, assume any obligations, or incur any expense other than for first aid to others that shall be imperative at the time of an accident.
- (8) **Action against Company, Coverages A and B:** No action shall lie against the Company unless as a condition precedent thereto the insured shall have fully complied with all the terms of this policy, nor until the amount of the insured's obligation to pay shall have been finally determined either by judgment against the insured after actual trial or by written agreement of the insured, the claimant, and the Company. Any person or organization or the legal representative thereof who has secured such judgment or written agreement shall thereafter be entitled to recover under this policy to the extent of the insurance afforded by this policy. No person or organization shall have any right under this policy to join the Company as a part to any action against the insured to determine the insured's liability. Bankruptcy or insolvency of the insured or of the insured's estate shall not relieve the Company of any of its obligations hereunder.
- (9) **Action against Company, Coverage C:** No action shall lie against the Company unless as a condition precedent thereto there shall have been full compliance with all the terms of this policy nor until 30 days after proof of loss is filed and the amount of loss is determined as provided in this policy.
- (10) **Insured's duties in event of loss, Coverage C:** In the event of loss, the insured shall protect the property, whether or not the loss is covered by this

policy. Any further loss attributable to the insured's failure to protect shall not be recoverable under this policy. Reasonable expenses incurred in affording such protection shall be deemed incurred at the company's request.

The insured shall also file with the Company, as soon as practicable after loss, his sworn proof of loss in such form and including such information as the Company may reasonably require and shall, upon the Company's request, exhibit the damaged property.

- (11) **Appraisal, Coverage C:** If the insured and the Company fail to agree as to the amount of loss, either may demand an appraisal of the loss within 60 days after the proof of loss is filed. In such event the insured and the Company shall each select a competent appraiser, and the appraisers shall select a competent and disinterested umpire. An award in writing or any two shall determine the amount of loss. The insured and the Company shall each pay his chosen appraiser and shall bear equally the other expenses of the appraisal and umpire. The Company shall not be held to have waived any of its rights by any act relating to appraisal.
- (12) **Payment of loss, Coverage C:** The Company may pay for the loss in money, but there shall be no abandonment of the damaged property to the Company.
- (13) **No benefit to bailee coverage:** The insurance afforded by this policy shall not enure directly or indirectly to the benefit of any carrier or bailee (other than the named insured) liable for loss to the property.
- (14) **Subrogation:** In the event of any payment under this policy, the Company shall be subrogated to all of the insured's rights of recovery therefor against any person or organization. The insured shall execute and deliver instruments and papers and do whatever else is necessary to secure such rights. The insured shall do nothing after loss to prejudice such rights.
- (15) **Application of insurance:** The insurance afforded by this policy is primary insurance. If the insured has other primary insurance against a loss covered by this policy, the Company shall not be liable under the policy for a greater proportion of such loss than the applicable limit of liability stated in the Contract bears to the total applicable limit of all valid and equitable insurance against such loss.
- (16) **3-year policy:** A policy period of 3 years is comprised of three consecutive annual periods. Computation and adjustment of earned premium shall be made at the end of each annual period. Aggregate limits of liability as stated in this policy shall apply separately to each annual period.
- (17) **Changes:** Notice to any agent of knowledge possessed by any agent or by any other person shall not affect a waiver or a change in any part of this policy or stop the Company from asserting any right under the terms except by endorsement issued to form a part of this policy signed by * _____ provided, however, changes may be made in the written portion of the Policy Declaration by * _____ when initialed

by such *_____ or by endorsement issued to form a part of this policy signed by such *_____. [*Insert titles of authorized company representatives.]

(18) **Assignment:** Assignment of interest under this policy shall not bind the Company until its consent is endorsed hereon.

(19) **Cancellation:** This policy may be cancelled by the named insured by mailing to the Company written notice stating when the cancellation shall become effective. This policy may be cancelled by the Company by mailing to the named insured, Contractor, and governmental authority at the respective addresses shown in this policy written notice stating when such cancellation shall be effective (not less than 30 days thereafter). The mailing of notice shall be sufficient proof of notice. The effective date and hour of cancellation stated in the notice shall become the end of the policy period. Delivery of such written notice either by the named insured or the Company shall be equivalent to mailing. If the named insured cancels, the earned premium shall be computed in accordance with the customary short rate table and procedure. If the Company cancels, the earned premium shall be computed pro rata. The premium may be adjusted either at the time cancellation is effected or as soon as practicable after the cancellation becomes effective, but payment or tender of unearned premium is not a condition of cancellation.

(20) **Policy Declarations:** By acceptance of this policy, the named insured agrees that such statements in the Policy Declarations as are made by him are his agreements and representations, that his policy is issued in reliance on the truth of such representations, and that this policy embodies all agreements existing between himself and the Company or any of its agents relating to this insurance.

e. For a policy issued by one company:

In witness whereof, the _____ Indemnity Company has caused this policy to be signed by its president and a secretary at _____ and countersigned on the Policy Declarations page by a duly authorized agent of the Company.

(Facsimile of Signature)
Secretary

(Facsimile of Signature)
President

For a policy issued by two companies:

In witness whereof, the _____ Indemnity Company has caused this policy with respect to Coverages _____ and such other parts of the policy as are applicable thereto to be signed by its president and a secretary at _____ and countersigned on the Policy Declarations page by a duly authorized agent of the Company.

(Facsimile of Signature)
Secretary

(Facsimile of Signature)
President

- (d) **Submitting Copies of Insurance Policies:** Prior to beginning construction operations on or over the railway right of way, the Contractor shall submit to the Department evidence of the railway company's approval and a copy of the required insurance policies. The Commonwealth will not be responsible for any claims from the Contractor resulting from delay in the acceptance of any of these policies by the railway company other than consideration of an extension of time. If the delay is caused by the failure of the Contractor or his insurer to file the required insurance policies promptly, an extension of time will not be granted.
- (e) **Beginning Construction:** Preliminary contingent work or other work by the railway company may delay the starting or continuous prosecution of the work by the Contractor. The Contractor shall be satisfied as to the probable extent of such work and its effect on the operations prior to submitting a bid for the work. The Commonwealth will not be responsible for any claims by the Contractor resulting from such delays except that an extension of time may be considered.
- (f) **Arranging for Tests:**
 - 1. **Railroad specifications:** When ordering materials that are to conform to railroad specifications, the Contractor shall notify the railway company, who will arrange for tests. The Contractor shall specify in each order that the materials are to be tested in accordance with the requirements of the railroad specifications and not those of the Department.
 - 2. **Highway Specifications:** When ordering materials that are to conform to highway Specifications, the Contractor shall specify in each order that the materials are to be tested in accordance with the requirements of Department Specifications.

107.20—Construction Over or Adjacent to Navigable Waters

The Department will obtain a permit from the U.S. Coast Guard for the anticipated construction and/or demolition activities of structures on Department projects that cross a waterway(s) under the jurisdiction of the U.S. Coast Guard. As the permit holder, the Department must apply to the U.S. Coast Guard for approval of permit modifications to the original Department permit that the Contractor requests.

Prior to starting demolition or construction operations the Contractor shall meet with the Engineer and the U.S. Coast Guard (U.S. Coast Guard Coordination Meeting) to present its planned operations and the potential impacts those operations may pose to water traffic. As part of this meeting, the parties shall establish in writing the proper protocol for emergency closures and be governed accordingly.

- (a) **Activities subject to Coast Guard regulation under the Permit.** Following the U.S. Coast Guard Coordination meeting, the Contractor shall submit its proposed schedule of operations in writing to the Engineer. The Engineer shall review and provide written comments, if applicable, to the Contractor within 7 calendar days following receipt of the Contractor's schedule of operations. The Contractor shall incorporate the Engineer's comments and submit its notice of scheduled operations to the Engineer and to the U.S. Coast Guard at least 30 days prior to commencement of any permitted construction or demolition operations. U.S. Coast Guard acceptance of the Contractor's written schedule of operations is a condition precedent to the Contractor's commencement of those operations.

- (b) **Activities that require channel closures or restrictions.** In addition to the submittal of its proposed schedule of operations as described in (a) above, Contractor shall submit plans that comply with the Permit for falsework, cofferdams, floating equipment and other obstructions to the channel or channels to the Engineer. The Contractor's attention is directed to the possibility that advance notification for consideration of approval may vary depending on the type and duration of proposed closures, the time of year for requested closure(s), and location of existing bridge(s) and waterway(s) involved, and the impact to entities served along or through the waterway(s). The Engineer shall review and provide written comments, if applicable, to the Contractor within thirty (30) calendar days following receipt of the Contractor's plans. The Contractor shall incorporate the Engineer's comments and submit its plans to the Engineer and to the U.S. Coast Guard at least 30 days prior to commencement of any permitted construction or demolition operations. The Contractor may not commence activities that require channel closures or restrictions without the prior written approval of the Department and the U.S. Coast Guard. The Contractor shall be responsible for complying with all operational requirements that the U.S. Coast Guard may place on the Contractor as conditions of approval.

In addition, the Contractor shall request and obtain Department and U.S. Coast Guard approval in writing before commencing any operations that deviate from the Contractor's schedule of operations when these operations interfere or have the potential to interfere with navigation of water traffic outside of timeframes previously approved by the Department and the U.S. Coast Guard.

Notices shall be sent to the U.S. Coast Guard, Fifth District Bridge Office (OBR), 431 Crawford Street, Portsmouth, VA 23704-5004. Payment of any penalty or fine that may be levied by the U.S. Coast Guard for Contractor violations of bridge regulations found in 33 CFR Parts 115, 116, 117 and 118 shall be the responsibility of the Contractor. Further, any delay to the contract as a result of actions or inaction by the Contractor relative to the requirements herein that are determined by the Department to be the fault of the Contractor will not be compensable.

The cost to comply with the requirements of this provision and to provide and maintain temporary navigation lights, signals and other temporary work associated with the structure(s) under this contract required by the U.S. Coast Guard for the protection of navigation during construction or demolition operations shall be included in price bid for other appropriate items.

107.21—Size and Weight Limitations

- (a) **Hauling or Moving Material and Equipment on Public Roads Open to Traffic:** The Contractor shall comply with legal size and weight limitations in the hauling or moving of material and equipment on public roads open to traffic unless the hauling or moving is covered by a hauling permit.
- (b) **Hauling or Moving Material and Equipment on Public Roads Not Open to Traffic:** The Contractor shall comply with legal weight limitations in the hauling or moving of material and equipment on public roads that are not open to traffic unless the hauling or moving is permitted elsewhere herein or is otherwise covered by a hauling permit. The Contractor shall be liable for damage that results from the hauling or moving of material and equipment. The hauling or moving of material and equipment on the pavement structure or across any structure during various stages of construction shall be subject to additional restrictions as specified or directed by the Engineer.

- (c) **Furnishing Items in Component Parts of Sections:** If the size or weight of fabricated or manufactured items together with that of the hauling or moving vehicle exceeds the limitations covered by hauling permit policies and other means of transportation are not available, permission will be given to furnish the items in component parts of sections with adequately designed splices or connections at appropriate points. Permission for such adjustments shall be requested in writing, and approval in writing shall be secured from the Department prior to fabrication or manufacture of the items. The request shall state the reasons for adjustment and shall be accompanied by supporting data, including working drawings where necessary.

SECTION 108—PROSECUTION AND PROGRESS OF WORK

108.01—Prosecution of Work

The Contractor shall begin work within 15 calendar days of the date of contract execution unless otherwise permitted by specific language in the Contract or as permitted by the provisions of Section 108.02.

Prior to beginning construction operations, the Contractor shall attend a pre-construction scheduling meeting to discuss the Contractor's general plan of operations, work times, and proposed means and methods for accomplishing the work. The pre-construction scheduling meeting may be held in conjunction with the pre-construction conference or in a separate meeting as mutually agreed to by the Department and the Contractor.

The Contractor shall provide a sufficient force of workers, materials, equipment, and tools; and shall prosecute the work with such diligence as is required to attain and maintain a rate of progress necessary to ensure completion of the project in accordance with the plans, specifications, and other requirements of the Contract.

Once the Contractor has begun work, it shall be prosecuted continuously and to the fullest extent possible except for authorized suspensions ordered by the Engineer as defined in Section 108.05. If approval is given to discontinue the work temporarily, the Contractor shall notify the Engineer at least 24 hours in advance of resuming operations.

At least once every 30 days or as specified in the contract documents, the Contractor shall meet with the Engineer to discuss his current progress relative to his Schedule of Record (SOR) and to establish the approximate date for starting each critical inspection stage during the following 30 days. The Engineer shall be advised at least 24 hours in advance of any changes in the Contractor's planned operations or critical stage work requiring inspection. For the purposes stated herein, the Schedule of Record (SOR) is defined in accordance with the provisions of Section 108.03.

Work shall be conducted in such a manner and with sufficient materials, equipment, tools, and labor as are necessary to ensure its completion in accordance with the plans and these Specifications within the time limit specified in the Contract Documents. Once the Contractor has begun work, it shall be prosecuted continuously and to the fullest extent possible except for interruptions caused by weather or delays authorized or ordered by the Engineer. If approval is given to discontinue the work temporarily, the Contractor shall notify the Engineer at least 24 hours in advance of resuming operations.

108.02—Limitation of Operations**(a) General**

The Contractor shall conduct the work in a manner and sequence that will ensure its expeditious completion with the least interference to traffic and shall have due regard for the location of detours and provisions for handling traffic. The Contractor shall not open any work to the prejudice or detriment of work already started. The Engineer may require the Contractor to finish a section of work before work is started on any other section.

(b) Holidays

Except as is necessary to maintain traffic, work shall not be performed on Sundays or the following holidays without the permission of the Engineer: January 1, Easter, Memorial Day, July 4, Labor Day, Thanksgiving Day, and Christmas Day.

If any of these holidays occurs on a Sunday, the following Monday shall be considered the holiday.

108.03—Progress Schedule General Requirements

The Contractor shall plan and schedule the work on the project so as to complete the work within the time limit and budget established by the contract and shall submit his plan to accomplish these objectives in the form of a Progress Schedule for the Engineer's review and acceptance. The Progress Schedule shall be used by the Engineer for planning, coordination and inspection activities, and for evaluation of the Contractor's rate of progress and the effects of time-related impacts on the project.

Prior to preparing the schedule, the Engineer or the Contractor may request a meeting to discuss any project specific items required for preparation of the progress schedule. The Contractor shall prepare and submit a practicable schedule to reflect a logical progress of the work. The progress schedule shall represent the Contractor's overall work plan to accomplish the work in accordance with the requirements herein and those of the Contract as detailed in the Contract documents. It shall include all time-based tasks required for timely completion of the work, including as applicable the work to be performed by sub-contractors, suppliers, the Department, and/or others. When preparing the schedule, the Contractor shall consider all applicable constraints and restrictions such as seasonal, weather, traffic, utility, railroad, right-of-way, environmental, permits, and other limitations to the work.

(a) Progress Schedule Requirements:

1. **Baseline Progress Schedule** – The Contractor shall submit to the Engineer his Baseline Progress Schedule at least 7 calendar days prior to beginning work. The Baseline Progress Schedule submittal shall include three (3) sets of a written Progress Schedule Narrative and, where applicable, a Progress Earnings Schedule as defined below:

- a) *Progress Schedule Narrative:* The Progress Schedule Narrative shall consist of the following information, as applicable:
 - i. A description of the Contractor's overall plan of operations including the planned procedures and crew(s) required to accomplish each major operation;

- ii. A Tabular Schedule to establish milestone(s) for completing each phase, feature, or stage of work as specified by contract or, where not specified by the contract, as determined by the Contractor. The schedule shall also indicate the planned sequence and start/finish dates for all time-based tasks required to complete each milestone;
 - iii. A discussion on the working calendar with considerations for applicable constraints or restrictions; (i.e. normal weather, traffic, holidays, time of year, utility, etc.);
 - iv. A description of any potential issues that may impact the schedule.
- b) *Progress Earnings Schedule*: Progress Earnings Schedule will not be required for projects with a contract duration of sixty (60) calendar days or less. The Progress Earnings Schedule shall be prepared on forms furnished by the Department to indicate the anticipated earnings for each payment period as of the Contractor's payment cut-off date as determined in accordance with Section 109.08. Progress earnings shall be based on the total contract value. Total contract value will be considered to mean the original amount of the contract including any authorized adjustments in accordance with, but not limited to, the provisions of Sections 104 and 109.05. Payments for stored or stockpiled material in accordance with Section 109.09 of the Specifications will not be considered in the earnings schedule.

2. **Revised Progress Schedule:**

The Contractor shall submit a Revised Progress Schedule as determined and requested by the Engineer, if prosecution of the work deviates significantly from the phasing, general sequence, or the proposed means and methods as represented on the Schedule of Record (SOR). The Contractor will also be required to submit a Revised Progress Schedule to reflect any impacts to the schedule for changes authorized by the Engineer including, but not limited to changes in the work in accordance with the requirements of Section 104 and Section 109.05 of the Specifications.

The Contractor shall submit the Revised Progress Schedule within 10 calendar days of the date of the Engineer's written request. The Revised Progress Schedule shall be in the form of a Revised Baseline Progress Schedule which shall reflect the actual progress of accomplished work (actual work to date), any impact of a change authorized by the Engineer, and the proposed time based plan for completing the remaining work. Upon acceptance by the Engineer, the latest Revised Progress Schedule shall replace the previously accepted Baseline or Revised Progress Schedule.

3. **Failure to Furnish Progress Schedules** – Work shall not commence until the Contractor submits his Baseline Progress Schedule in accordance with the requirements of this section, unless otherwise approved in writing by the Engineer.

Delays in work resulting from the Contractor's failure to provide the progress schedule will not be considered just cause for extension of the contract time limit or for additional compensation.

(b) **Review and Acceptance**

The Engineer will review all progress schedule submittals within 7 calendar days of receipt of the Contractor's complete submittal. Review and acceptance by the Engineer will be based on completeness and conformance with the requirements of this section, the Contract and the Specifications. If the Contractor's Progress Schedule is deemed to be unacceptable, the Engineer will issue a written notification for resubmission describing the deficiencies in completeness or conformance prompting the Engineer's decision.

Upon acceptance, the Engineer will issue a written notice of acceptance that may include comments or concerns on the schedule. The Contractor shall respond within 7 calendar days of receipt of the Engineer's comments, concerns or written notification for resubmission.

Upon acceptance, the latest Baseline Progress Schedule or Revised Progress Schedule shall become the Schedule of Record (SOR). The SOR is defined as the currently accepted progress schedule by which all schedule references will be made and progress evaluated.

Review and acceptance by the Engineer will not constitute a waiver of any contract requirements and will in no way assign responsibilities of the work plan, scheduling assumptions, and validity of the schedule to the Department. Failure of the Contractor to include in the Progress Schedule any element of work required for timely completion of the project shall not excuse the Contractor from completing the entire scope of work within the Contract specified completion milestone(s).

(c) Monitoring the Work and Assessing Progress

1. **Monitoring the Work**– The Engineer will monitor the work regularly to identify any deviations from the Contractor's scheduled performance relative to the currently accepted Baseline or Revised Progress Schedule. The Engineer may request a meeting with the Contractor to discuss the Contractor's current progress or to establish the approximate date for starting each critical inspection stage during the following 30 days. At least once a week, the Contractor shall advise the Engineer of the approximate timing for anticipated critical stages for the subsequent week. The Engineer shall be advised at least 24 hours in advance of any changes in the Contractor's planned operations or critical stage work requiring Department inspection.
 2. **Progress Evaluation**– The Engineer will evaluate the Contractor's progress monthly relative to the currently accepted Baseline or Revised Progress Schedule. The Contractor's actual progress may be considered unsatisfactory if:
 - a) The cumulative actual earnings for work completed is 10 or more percentage points behind the cumulative earnings for work scheduled; or
 - b) Any interim milestone is later than the scheduled milestone by more than 7 calendar days or the projected project completion date is later than the contract completion date by the least of 14 calendar days or 10 percent of the remaining contract time.
- (d) **Progress Deficiency and Schedule Slippage:** When the Contractor's actual progress is deemed to be unsatisfactory, the Engineer will issue a written notice of unsatisfactory performance to indicate that further actions may be taken as defined in Sections 102.01 and 109.08 of the Specifications, if progress remains unsatisfactory at the time of preparation of the next monthly progress estimate. Within 10 calendar days of the date of the Engineer's

notice of unsatisfactory progress, the Contractor may submit to the Engineer, a recovery plan to reflect a proposed plan to correct the progress deficiency or schedule slippage, or submit to the Engineer a written explanation and supporting documentation to establish that such delinquency is due to conditions beyond the Contractor's control. Any schedule revisions resulting from a recovery plan will be reviewed in accordance with subsection (c) herein, but shall not replace the SOR.

108.04—Determination and Extension of Contract Time Limit

The Contract time limit for completion will be determined by the Department and specified in the Contract Documents. No request for an extension of time will be considered that is based on any claim that the contract time limit as originally established was inadequate.

With a fixed date contract when the date of contract execution is not within 60 calendar days after the opening of bids, or when the Contractor is unable to commence work because of any failure of the Department, or when the Contractor is delayed because of the fault of the Department, the Contractor will be given an extension of time based on the number of days delayed beyond the 60 calendar days. No time extension will be allowed for a delay in the date of contract execution when the delay is the fault of the Contractor.

The Engineer will determine if an extension of the Contract time limit for completion is warranted by additions to the Contract. The Contractor shall inform the Department, in writing, of a request for time extensions in his Work Order in accordance with the applicable portion(s) of Section 104 or 109. The Contractor shall provide written supporting data for any request for extension of time due to quantity additions and or additional or altered work.

During prosecution of the work, the Contractor shall identify the causes for any delays attributable to conditions he deems to be beyond his control and shall identify the particular construction operations affected, their criticality to project milestones or overall contract completion, and the significant dates that encompass the periods of delay. The Contractor shall furnish all such information necessary for the Department to make an adequate evaluation of any claim received from the Contractor for an extension of the contract time limit within three days of experiencing such a delay.

- (a) **Fixed Date:** Unless otherwise indicated in the Contract, the contract time limit will be specified as a fixed date for completion. The Contractor shall take into consideration normal conditions considered unfavorable for the prosecution of the work, and shall place sufficient workers and equipment on the project to complete the work in accordance with the specified contract time limit.

The Engineer may give consideration for extension of time when a delay occurs due to unforeseen causes beyond the control of or without the fault or negligence of the Contractor. However, consideration will not be given to extensions of time attributable to normal weather conditions or conditions resulting from normal weather.

For the purposes of this Section normal weather is defined as that which is not considered extraordinary or catastrophic and is not reasonably conducive to the Contractor progressively prosecuting critical path work under the Contract. Weather events considered extraordinary or catastrophic include, but are not limited to tornados, hurricanes, earthquakes, and floods that exceed a 25-year storm event as defined by National Oceanic and Atmospheric

Administration (NOAA) for the NOAA data gathering location that is nearest the project site.

If there is a delay in the progress of the work due to unforeseen causes described within these Specifications, and the delay extends the contract time limit into the period between November 30 of one year and April 1 of the following year and working conditions during such period are unsuitable for the continuous prosecution **or** completion of the work, then consideration may only be given to granting an extension of time that will encompass a suitable period during which such work can be expeditiously and acceptably performed.

108.05—Suspension 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 and/or contract time is due as a result of such suspension or delay, the Contractor shall submit to the Engineer in writing a request for adjustment within seven calendar days of receipt of the notice to resume work. The request shall set forth the reasons and support for such adjustment.

Upon receipt, the Engineer will review the Contractor's documentation and evaluate the Contractor's request. If the Engineer agrees that the cost and/or time required for the performance of 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, his suppliers, or subcontractors at any approved tier, and was not caused by normal weather, the Engineer will make an adjustment (excluding profit) and modify the contract in writing accordingly. The Engineer will notify the Contractor of the determination regarding whether or not an adjustment of the contract is warranted.

No contract adjustment will be allowed unless the Contractor has submitted the request for adjustment within the time prescribed.

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

108.06—Failure To Complete on Time

(a) General

For each calendar day that any work remains incomplete after the contract time limit specified for the completion of the work, the Department will assess liquidated damages against the Contractor. Liquidated damages will be assessed at the rate applicable to the Contract in accordance with the Schedule of Liquidated Damages, Table I-1, or as otherwise specified in the contract provisions. Liquidated damages will be deducted from any monies due the Contractor for each calendar day of additional time consumed until final completion and acceptance of the work, subject to such adjustments as provided in accordance with the requirements of Section 108.04, not as a penalty, but as liquidated damages.. The Contractor waives any defense as to the validity of any liquidated damages stated in the Contract, the Contract Documents, or these Specifications and assessed by the Department against the

Contractor on the grounds that such liquidated damages are void as penalties or are not reasonably related to actual damages.

(b) **Liquidated Damages.**

The following Schedule of Liquidated Damages, representing the cost of administration, engineering, supervision, inspection and other expenses, will be charged against the Contractor for each calendar day beyond the fixed contract time that the Contract remains in an incomplete state:

**TABLE I-1
Schedule of Liquidated Damages**

Original Contract Amount in Dollars	Daily Charge in Dollars
0 – 500,000.00	350
500,000.01 – 2,000,000.00	600
2,000,000.01-8,000,000.00	1,350
8,000,000.01- 15,000,000.00	2,500
15,000,000.01- Plus	3,100

108.07—Default of Contract

The Contractor may be declared in default if he does *any* one of the following:

- (a) fails to begin the work under the Contract within 15 calendar days of the date of contract execution except as otherwise permitted by specific contract language or the provisions of Section 108.02.
- (b) fails to perform the work with sufficient workers and equipment or with sufficient materials to ensure prompt completion of the work
- (c) performs the work unsuitably or neglects or refuses to remove materials or perform anew work that is unacceptable
- (d) discontinues prosecution of the work
- (e) fails to resume work that has been discontinued within a reasonable time after notice to do so
- (f) becomes insolvent, is declared bankrupt, or commits any act of bankruptcy or insolvency
- (g) allows any final judgment to stand against him unsatisfied for a period of 10 days
- (h) makes an assignment for the benefit of creditors, or
- (i) fails for any other cause whatsoever to carry on the work or contractual obligations in an acceptable manner

If any of these conditions exists, the Engineer will give notice in writing to the Contractor and his surety of the delay, neglect, or default. If within 10 days after the date of such notice the Contractor or his surety has not taken measures that will, in the judgment of the Chief Engineer, ensure satisfactory progress of the work or give assurances satisfactory to the Engineer that the provisions of the Contract will be fully carried out and instructions complied with, the Commissioner may then, or at any time thereafter, declare the Contractor in default. Without violating the Contract, the Commissioner may call upon the Contractor's surety for the satisfactory and expeditious completion of all work under the Contract or may otherwise terminate the Contract in accordance with the provisions of Section 108.08.

If the Contractor is declared in default, subsequent payments will be made to the surety and further negotiations will be conducted with the surety.

If the Contractor's surety fails or refuses to proceed with the work in accordance with the instructions of the Commissioner, the Commissioner will appropriate and use any or all materials and equipment on the project site that are suitable and acceptable and will enter into an agreement with others for the completion of the work, or he will use such other methods as he deems necessary to ensure the completion of the work.

Costs and charges incurred by the Department, including the cost of completing the work under the Contract, will be deducted from any monies due or that will become due the Contractor and his surety. If the expense incurred by the Department is less than the sum that would have been payable under the Contract had the work been completed by the Contractor, the Contractor and his surety will be entitled to receive the difference. If the expense exceeds the sum that would have been payable under the Contract, the Contractor and his surety shall be liable for and shall pay to the Commonwealth the amount of the excess.

108.08—Termination of Contract

- (a) **Conditions for Termination:** The Department may terminate the Contract or any portion thereof because of *any* of the following conditions:
1. default
 2. national emergency
 3. action by the Commonwealth, U.S. government, or court order, or
 4. conditions beyond the control of the Department
- (b) **Provisions of Termination:** Termination will be in accordance with the following:
1. Disturbed areas shall be promptly placed in an acceptable condition as directed by the Engineer. Payment for such work will be made at the contract unit prices or, in the absence of contract unit prices, in accordance with the requirements of Section 104.03.
 2. Payment will be made for the actual number of units or items of work completed at the contract unit price, or as mutually agreed, for items of work partially completed. No claim for loss of anticipated profits will be considered, and the provisions of Section 104.02 will not apply.

3. Reimbursement for organizing the work when not specified in the Contract and moving equipment to and from the job will be considered where the volume of work completed is too small to compensate the Contractor for these expenses under the contract unit prices.
4. At the option of the Engineer, materials the Contractor obtains for the work that have been inspected, tested, and accepted by the Engineer and that have not been incorporated in the work may be purchased from the Contractor at actual costs as shown by receipted bills, purchase orders, bills of lading or other similar actual cost records at such points of delivery as may be designated by the Engineer.
5. The termination of the Contract or a portion thereof shall not relieve the Contractor of his responsibilities for the completed work, nor shall it relieve his surety of its obligation for and concerning any just claims arising out of the work performed or remaining to be performed.

108.09—Acceptance

- (a) **Contractor's Responsibility for Work:** Until final acceptance of the work by the Engineer in accordance with the requirements of this Section, the Contractor shall have charge and care thereof and shall take every precaution against damage to any part thereof by action of the elements or from any other cause. The Contractor shall rebuild, repair, restore, and make good on damage to any portion of the work occasioned by any of the foregoing causes before final acceptance and shall bear the expense thereof. The Department may reimburse the Contractor for repair of damage to work attributable to unforeseeable causes beyond the control of and without the fault or negligence of the Contractor as determined by the Engineer.

In case of suspension of work, the Contractor shall be responsible for the project and shall take such precautions as may be necessary to prevent damage to the work, provide for erosion control and drainage, and erect any necessary temporary structures, signs, or other facilities as determined by the Engineer. During the suspension of work, the Contractor shall properly and continuously maintain in an acceptable growing condition all living material in newly established plantings, seedings, and soddings furnished under the Contract and shall take adequate precautions to protect new tree growth and other important vegetation against damage.

- (b) **Partial Acceptance:** If at any time during the prosecution of the project the Contractor completes a unit or portion of the project, such as a structure, an interchange, slopes, pavement, or a section of a roadway in its entirety, he may ask the Engineer to make final inspection of such work. If the Engineer finds upon inspection that the work conforms to the requirements of the Contract and that acceptance is in the best interest of the public, he may accept the work as being completed, and the Contractor will be relieved of further responsibility for the work. Partial acceptance shall in no way void or alter any terms of the Contract.

If any damage is sustained by an accepted unit or portion of the project attributable to causes beyond the control of the Contractor, the Engineer may authorize the Contractor to make the necessary repairs. These repairs will be paid for at the contract price for the items

requiring repair. In the absence of contract prices covering the items of repair, the work will be paid for in accordance with the requirements of Section 109.05.

- (c) **Final Acceptance:** Upon receipt of a written notice from the Contractor of presumptive completion of the entire project, the Engineer will make an inspection. If all work specified in the Contract has been completed, the inspection will constitute the final inspection and the Engineer will make the final acceptance. The Contractor will be notified in writing, of the determination of final acceptance within five days of the date of the Engineer's final acceptance..

If the Engineer's inspection discloses that any work, in whole or in part, is incomplete or unacceptable, the Contractor shall immediately correct the deficiency. A written list of deficiencies will be provided to the Contractor by the Engineer. Upon completion or correction of the work, another inspection will be made of the deficient work. If the work is then satisfactory, the Engineer will notify the Contractor in writing within five days of the Engineer's final acceptance. In any event, the Contractor shall be responsible for and maintain the project until final acceptance except under conditions that may be specifically exempted by the Specifications or specific contract language.

108.10—Termination of Contractor's Responsibilities

The Contract will be considered complete upon final acceptance. The Contractor's responsibility to the work of the Contract will then cease except as set forth in his bond and the requirements of Sections 109.08 and 109.10.

SECTION 109—MEASUREMENT AND PAYMENT

109.01—Measurement of Quantities

Work specified in the Contract will be measured by the Engineer in accordance with U.S. Standard Measure. The methods of measurement and computations to be used to determine quantities of material furnished and work performed will be those generally recognized as conforming to good engineering practice.

Specific methods of measurement shall be as indicated in the specific section for the pay item.

Longitudinal measurements for surface area computations will be made along the surface, and transverse measurements will be the surface measure shown on the plans or ordered in writing by the Engineer. Individual areas of obstructions with a surface area of 9 square feet or less will not be deducted from surface areas measured for payment.

Structures will be measured in accordance with the neat lines shown on the plans.

Items that are measured by the linear foot will be measured parallel to the base or foundation upon which they are placed.

Allowance will not be made for surfaces placed over an area greater than that shown on the plans or for any material moved from outside the area of the cross-section and lines shown on the plans.

When standard manufactured items are specified and are identified by weights or dimensions, such identification will be considered nominal. Unless more stringently controlled by tolerances in cited specifications, manufacturing tolerances established by the industries involved will be accepted.

- (a) **Measurement by Weight:** Materials that are measured or proportioned by weight shall be weighed on accurate scales as specified in this Section. When material is paid for on a tonnage basis, personnel performing the weighing shall be certified by the Department and shall be bonded to the Commonwealth of Virginia in the amount of \$10,000 for the faithful observance and performance of the duties of the weighperson required herein. The bond shall be executed on a form having the exact wording as the Weighpersons Surety Bond Form furnished by the Department and shall be submitted to the Department prior to the furnishing of the tonnage material. No payment will be made for materials delivered in excess of the legal load limits established for each truck.

The Contractor shall have the weighperson perform the following:

1. Post and furnish a weekly tare weight of each truck used and keep a record of them for 12 months.
2. Furnish a signed weigh ticket for each load that shows the date, truck number, load number, plant name, size and type of material, project number, schedule or purchase order number, and the weights specified herein.
3. Maintain sufficient documentation so that the accumulative tonnage and distribution of each lot of material, by contract, can be readily identified.
4. Submit by the end of the next working day a summary of the number of loads and total weights for each type of material by contract.

Trucks used to haul material being paid for by weight shall display the truck uniform identification number and legal gross and legal net weight limits. These markings shall be no less than 2 inches high and permanently stenciled on each side of the truck with contrasting color and located as to be clearly visible when the vehicle is positioned on the scales and observed from normal position of the weighperson at the scale house.

Trucks used to haul material shall be equipped with a cover suitable to protect the material and to protect the traveling public.

The truck tare to be used in the weighing operation shall be the weight of the empty truck determined with full tank(s) of fuel and the operator seated in the cab. The tare weight of trucks shall be recorded to the nearest 20 pounds. At the option of the Contractor, a new tare may be determined for each load. When a new tare is obtained for each load, the requirement for full tank(s) of fuel will be waived.

Net rail shipment weights may be used for pay quantities when evidenced by railroad bills of lading. However, such weights will not be accepted for pay quantities of materials that subsequently pass through a stationary mixing plant.

Scales shall conform to the requirements for accuracy and sensitivity as set forth in the *National Institute of Standards and Technology Handbook No. 44 for Specification Tolerances and Requirements for Commercial and Weighing Devices*. Scales used in the weighing of materials paid for on a tonnage basis shall be approved and sealed in accordance with the requirements of the policies of the Bureau of Weights and Measures of the Department of Agriculture and Consumer Services, or other approved agencies, at least once every six months and upon being moved. Hopper and truck scales shall be serviced and tested by a scale service representative at least once every six months. Hopper scales shall be checked with a minimum 500 pounds of test weights and truck scales shall be checked with a minimum 20,000 pounds of test weights.

Copies of scale test reports shall be maintained on file at the scale location for at least 18 months, and copies of all scale service representative test reports shall be forwarded to the Department.

The quantity of materials paid for on a tonnage basis shall be determined on scales equipped with an automatic printer. Truck scale printers shall print the net weight and either the gross or tare weight of each load. Hopper scale printers shall print the net weight of each load. The weigh ticket shall also show the legal gross weight for material weighed on truck scales and the legal net weight for material weighed on hopper scales.

If the automatic printer becomes inoperative, the weighing operation may continue for 48 hours provided satisfactory visual verification of weights can be made. The written permission of the District Materials Engineer shall be required for the operation of scales after 48 hours.

If significant discrepancies are discovered in the printed weight, the ultimate weight for payment will be calculated on volume measurements of the materials in place and unit weights determined by the Engineer or by other methods deemed appropriate to protect the interests of the Commonwealth.

- (b) **Measurement by Cubic Yard:** Material that is measured by the cubic yard, loose measurement or vehicular measurement, shall be hauled in approved vehicles and measured therein at the point of delivery. Material measured in vehicles, except streambed gravel, will be allowed at the rate of $\frac{2}{3}$ the volume of the vehicle. The full volume of the vehicle will be allowed for streambed gravel. Such vehicles may be of any size or type acceptable to the Engineer provided the body is of such shape that the actual contents can be readily and accurately determined. Unless all approved vehicles are of uniform capacity, each vehicle shall bear a plainly legible identification mark indicating the specific approved capacity. Each vehicle shall be loaded to at least its water level capacity.

When approved by the Engineer in writing, material specified to be measured by the cubic yard may be weighed and such weights converted to cubic yards for payment purposes. Factors for conversion from weight to volume measurement will be determined by the Engineer and shall be agreed to by the Contractor before they are used.

- (c) **Measurement by Lump Sum:** When used as an item of payment, the term *lump sum* will mean full payment for completion of work described in the Contract. When a complete structure or structural unit is specified as a pay item, the unit of measurement will be lump sum, and shall include all necessary fittings and accessories. The quantities may be shown on the plans for items for which lump sum is the method of measurement. If shown, the

quantities are approximate and are shown for estimating purposes only. Items that are to be measured as complete units will be counted by the Inspector in the presence of a representative of the Contractor.

(d) **Specific Items:**

1. **Concrete (Measured by Volume Measure):** Concrete will be measured and computed by dividing the work into simple geometrical figures and adding their volumes.
2. **Concrete (Measured by Square or Lineal Measure):** Concrete will be measured and computed by dividing the work into simple geometrical figures and adding their areas or measuring linearly along the item's surface .
3. **Excavation, embankment, and borrow:** In computing volumes of excavation, embankment, and borrow, methods having general acceptance in the engineering profession will be used. When the measurement is based on the cross-sectional area, the average end area method will be used.
4. **Asphalt:** Asphalt will be measured by the gallon, volumetric measurement, based on a temperature of 60 degrees F using the following correction factors:
 - a. 0.00035 per degree F for petroleum oils having a specific gravity 60/60 degrees F above 0.966
 - b. 0.00040 per degree F for petroleum oils having a specific gravity 60/60 degrees F between 0.850 and 0.966
 - c. 0.00025 per degree F for emulsified asphalt

Unless volume correction tables are available, the following formula shall be used in computing the volume of asphalt at temperatures other than 60 degrees F:

$$V^1 = V/K(T - 60) + 1$$

Where:

- V = volume of asphalt to be corrected;
- V^1 = volume of asphalt at 60 degrees F;
- K = correction factor (coefficient of expansion); and
- T = temperature in degrees F of asphalt to be corrected.

When asphalt is delivered by weight, the volume at 60 degrees F will be determined by dividing the net weight by the weight per gallon at 60 degrees F.

When specified in the Contract, asphalt will be measured by weight. Net certified scale weights, or weights based on certified volumes in the case of rail shipments, will be used as a basis of measurement, subject to correction when asphalt has been lost from the car or the distributor, disposed of, or otherwise not incorporated in the work.

When asphalt is shipped by truck or transport, net certified weights or volumes subjected to correction for loss or foaming may be used to compute quantities.

Only the quantity of asphalt actually placed in the work and accepted will be considered in determining the amount due the Contractor.

5. **Timber:** Timber will be measured in units of 1,000 foot-board-measure actually incorporated in the structure. Measurement will be based on nominal widths and thicknesses and the extreme length of each piece.

109.02—Plan Quantities

When specified in the Contract, items will be measured and paid for on the basis of plan quantities. The quantities allowed for compensation will be those shown on the plans with deductions from or authorized additions to such quantities resulting from deviations from the plans. In the case of excavation, only excavation within the cross-section prism will be paid for on a plan quantity basis.

If the Contractor believes that any plan quantity is incorrect, he may solicit, at his own expense, the aid of a certified Professional Engineer registered in the Commonwealth of Virginia to check the quantity or he may ask the Department in writing to check computations of the quantity. Written requests for a quantity check by the Department shall be accompanied by calculations, drawings, or other evidence indicating why the plan quantity is believed to be in error. If any item of the Contract is found to be in error and so verified by the Engineer, payment will be made in accordance with the corrected plan quantity.

If the Department determines during construction that there is an error in the plan quantity, or that conditions vary from those anticipated in the design to the extent that an actual measurement of a plan quantity item is warranted, the Department will make such measurement and will notify the Contractor, in writing, of the rationale for adjustment. Payment will then be based on the measured quantity in lieu of the plan quantity.

109.03—Scope of Payment

Payments to the Contractor will be made for the quantities of contract items performed in accordance with the plans and the requirements of the Specifications. If, upon completion of the construction, these quantities show either an increase or decrease from the quantities shown in the Contract, the contract unit prices shall prevail and payment will be made for actual quantities performed unless they have been modified by work orders.

Quantities appearing on the proposal are estimated quantities for the basic design shown on the plans. With the approval of the Department, the Contractor may furnish other design(s) that may involve changes in quantities or the use of different materials. However, payment will be made for the original quantities listed in the Contract only and in the units of measure given in the Contract for the basic design unless the dimensions for the basic design are changed by an authorized modification by work order to conform to field conditions encountered. In this event, modified plan quantities will be used for pay quantities at contract unit prices for the items listed on the proposal.

The Contractor shall accept the compensation provided for in the Contract as full payment for the following:

- (a) furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work

- (b) performing all work specified in the Contract
- (c) all loss or damage arising from the nature of the work or from action of the elements or any other unforeseen difficulties that may be encountered during prosecution of the work and until its final acceptance
- (d) any infringement of patent, trademark, or copyright
- (e) the completion of the work in accordance with the requirements of the Contract

If the payment clause in the Specifications relating to any unit price in the Contract requires that the unit price cover and be considered compensation for certain work or material essential to the item, the work or material will not be measured or paid for under any other item except as provided in Section 106.05.

The payment of any partial estimate or any retained percentage prior to final acceptance of the project as provided for in Section 108.09 shall in no way affect the obligation of the Contractor to repair or renew any defective parts of the construction or to be responsible for all damages attributable to such defects.

109.04—Compensation for Altered Quantities

When the accepted quantities of work vary from the estimated quantities set forth in the Contract but such variance is within the percentage limits set forth in Section 104.02 whether or not there have been any changes in the plans, the Contractor shall accept as payment in full, so far as contract items are concerned, payment at the original contract unit prices for the accepted quantities of work performed. No allowance or other adjustment except as provided for in Section 104.02 will be made for any increased expense, loss of expected reimbursement, or loss of anticipated profits suffered or claimed by the Contractor resulting directly from either such alterations or unbalanced allocation among the contract items of overhead expense on the part of the Contractor and subsequent loss of expected reimbursements therefor or from any other cause except the payment for the actual quantity performed at the original contract unit price.

Alterations of plans or character of work involving authorized work orders as provided for in Section 104.02 will be paid for in accordance with the requirements of Section 104.02.

109.05—Extra and Force Account Work

The Department may add any new, unforeseen or unanticipated work that in the judgment of the Engineer is necessary for the satisfactory fulfillment of the Contract within its intended scope. This extra work may be accomplished by work order if the scope is defined, or on a force account basis if the scope is not defined. Extra work or force account work may be necessitated in accordance with the provisions of Sections 104.02 or 104.03 as applicable. The Engineer will advise the Contractor in writing of the necessity for such extra work at the time of discovery or determination of need. Where possible, the Department and Contractor will each proceed to secure any information, documentation or plans to assist in detailing the extent and character of such work, if known, in sufficient detail to define, analyze and estimate the cost and time required to perform the work.

A. Work Orders

When the Contractor believes extra work is warranted he shall promptly notify the Engineer in writing within 2 days of such a determination. Should the Engineer agree with the Contractor's assessment of extra work then within 7 days or as mutually decided with the Engineer, the Contractor shall determine the extent of such work and detail in his request what additional compensation and/or time he seeks, if any, relative to his determination. The Contractor's submittal shall be in sufficient detail to enable the Engineer to determine the basis for entitlement. Failure on the part of the Contractor to furnish sufficient documentation or to qualify his reason for failure to do so will delay the determination of entitlement for such work. If such delay occurs, it will in no way relieve the Contractor of his obligation to meet the time limits or other requirements established for the contract or constitute basis for a delay claim on the part of the Contractor.

Prior to the actual execution of a work order the Engineer will require the Contractor to provide unit prices for the proposed work, and any requested contract time extension.

If the Contractor requests a time extension, the proposed time extension will only be considered if the work is a controlling work item or affects the critical path for a project milestone or project completion. Any justifiable time extension given must be included at the time the work order is developed. For projects without a critical path method scheduling specification, the Contractor shall include detailed information on how the controlling item of work was affected in accordance with the requirements detailed in that specification. Any time extension given on a Fixed Date contract, including time extensions in accordance with the requirements of Section 108.04 of the Specifications, must be added to the contract by work order.

Upon receipt and review of the Contractor's costs for the proposed work, if it is found that the Contractor's prices and/or the time differ considerably from the Department's estimate, the Engineer may request the Contractor to provide support for his unit prices and/or his requested time extension. Where the Department and the Contractor can determine and agree upon an accurate cost and time estimation for the proposed work the Engineer will issue a bilateral work order to authorize the work. When the Contractor and the Department cannot agree upon the cost and/or the time estimation for the extra work after the Engineer's analysis and subsequent discussion with the Contractor, or where due to issues of emergency, safety, environmental damage, other similar critical factors as determined by the Department, the Engineer will act unilaterally and issue a unilateral work order to authorize the work. The issuance of a unilateral work by the Engineer shall in no way invalidate or relinquish the Contractor's rights under the provisions of Section 105.19.

B. Force Account

The Department will require the Contractor to proceed with additional work on a force account basis when neither the Department nor the Contractor can firmly establish an applicable estimate for the cost of the work because the scope of the work is not known; that is, the level of effort required to perform and complete the work is unknown or not quantifiable at the time of discovery or start of the extra work, and will be determined as work progresses. The rates for labor, equipment and materials to be used in cases of work performed on a force account basis will be compensated in the following manner:

- (a) **Labor:** Unless otherwise approved, the Contractor will receive the rate of wage or scale as set forth in his most recent payroll for each classification of laborers, forepersons, and su-

perintendent(s) who are in direct charge of the specific operation. The time allowed for payment will be the number of hours such workers are actually engaged in the work. If overtime work is authorized, payment will be at the normal overtime rate set forth in the Contractor's most recent payroll. If workers performing the class of labor needed have not been employed on the project, mutually agreed on rates will be established. However, the rates shall be not less than those predetermined for the project, if applicable. An amount equal to 45 percent of the approved force account payroll will be included in the payment for labor to cover administrative costs, profit, and benefits and/or deductions normally paid by the Contractor.

- (b) **Insurance and Tax:** The Contractor will receive an amount equal to 25 percent of the approved force account payroll exclusive of additives of administrative cost as full compensation for property damage and liability, workers' compensation insurance premiums, unemployment insurance contributions, and social security taxes of force account work.
- (c) **Materials:** The Contractor will receive the actual cost of materials accepted by the Engineer that are delivered and used for the work including taxes, transportation, and handling charges paid by the Contractor, not including labor and equipment rentals as herein set forth, to which 15 percent of the cost will be added for administration and profit. The Contractor shall make every reasonable effort to take advantage of trade discounts offered by material suppliers. Any discount received shall pass through to the Department. Salvageable temporary construction materials will be retained by the Department, or their appropriate salvage value shall be credited to the Commonwealth, as agreed on by the Department.
- (d) **Equipment:** The Contractor shall provide the Engineer a list of all equipment to be used in the work. For each piece of equipment, the list shall include the serial number; date of manufacture; location from which equipment will be transported; and, for rental equipment, the rental rate and name of the company from which it is rented. The Contractor will be paid rental rates for pieces of machinery, equipment, and attachments necessary for prosecution of the work that are approved for use by the Engineer. Equipment rental will be measured by time in hours of actual time engaged in the performance of the work and necessary traveling time of the equipment within the limits of the project or source of supply and the project. Hourly rates will not exceed 1/176 of the monthly rates of the schedule shown in the *Rental Rate Blue Book* modified in accordance with the *Rental Rate Blue Book* rate adjustment tables that are current at the time the force account is authorized. Adjustment factors or rate modifications indicated in the *Rental Rate Blue Book* will not be considered when acceptable rates are determined. Hourly rates for equipment on standby, will be at 50 percent of the rate paid for equipment performing work. Operating costs shall not be included in the standby rate. For the purposes herein "standby time" is defined as the period of time equipment ordered to the jobsite by the Engineer is available on-site for the work but is idle for reasons not the fault of the Contractor or normally associated with the efficient and necessary use of that equipment in the overall operation of the work at hand.

Payment will be made for the total hours the equipment is performing work. When equipment is performing work less than 40 hours for any given week and is on standby, payment for standby time will be allowed for up to 40 hours, minus hours performing work. Payment will not be made for the time that equipment is on the project in excess of 24 hours prior to its actual performance in the force account work. An amount equal to the *Rental Rate Blue Book* estimated operating cost per hour will be paid for all hours the equipment is performing work. This operating cost shall be full compensation for fuel, lubricants, repairs, greas-

ing, fueling, oiling, small tools, and other incidentals. No compensation will be paid for the use of machinery or equipment not authorized by the Engineer.

The Contractor will be paid freight cost covering the moving of equipment to and from the specific force account operation provided such cost is supported by an invoice showing the actual cost to the Contractor. However, such payment will be limited to transportation from the nearest source of available equipment. If equipment is not returned to the nearest equipment storage lot but is moved to another location, the freight cost paid will not exceed the cost of return to the nearest storage lot.

The rates for equipment not listed in the *Rental Rate Blue Book* schedule shall not exceed the hourly rate being paid for such equipment by the Contractor at the time of the force account authorization. In the absence of such rates, prevailing rates being paid in the area where the authorized work is to be performed shall be used.

If the Contractor does not possess or have readily available equipment necessary for performing the force account work and such equipment is rented from a source other than a company that is an affiliate of the Contractor, payment will be based on actual invoice rates, to which 15 percent of the invoice cost will be added for administrative cost and profit. If the invoice rate does not include the furnishing of fuel, lubricants, repairs, and servicing, the invoice rate will be converted to an hourly rate, and an amount equal to the *Rental Rate Blue Book* estimated operating cost per hour will be added for each hour the equipment is performing work.

- (e) **Miscellaneous:** No additional allowance will be made for attachments that are common accessories for equipment as defined in the *Rental Rate Blue Book*, general superintendents, timekeepers, secretaries, the use of small hand held tools or other costs for which no specific allowance is herein provided. The Contractor will receive compensation equal to the cost of the bond, special railroad insurance premiums, and other additional costs necessary for the specific force account work as determined by the Department. The Contractor shall supply documented evidence of such costs.
- (f) **Compensation:** The compensation as set forth in this Section shall be accepted by the Contractor as payment in full for work performed on a force account basis. At the end of each day, the Contractor's representative and the Inspector shall compare and reconcile records of the hours of work and equipment, labor and materials used in the work as ordered on a force account basis. Such accounting may not include actual costs or labor rates where these are not available but shall be used to verify quantities, types of materials or labor, and number and types of equipment.

If all or a portion of the force account work is performed by an approved subcontractor, the Contractor will be paid 10 percent of the subcontract net force account costs to cover the Contractor's profit and administrative cost. The amount resulting will not be subject to any further additives. The itemized statements of costs as required below shall be submitted on a form that separates the subcontracted portions of the force account labor, materials, and equipment from the other force account costs.

- (g) **Statements:** Payments will not be made for work performed on a force account basis until the Contractor has furnished the Engineer duplicate itemized statements of the cost of such work detailed as follows:

1. payroll indicating name, classification, date, daily hours, total hours, rate, and extension of each laborer, foreperson, and superintendent
2. designation, dates, daily hours, total hours, rental rate, and extension for each unit of equipment
3. quantities of materials, prices, and extensions
4. transportation of materials

Statements shall be accompanied and supported by invoices for all materials used and transportation charges. However, if materials used on the force account work are not specifically purchased for such work but are taken from the Contractor's stock, then in lieu of the invoices, the Contractor shall furnish an affidavit certifying that such materials were taken from his stock; that the quantity claimed was actually used; and that the price, transportation, and handling claimed represented his actual cost.

109.06—Common Carrier Rates

The common carrier rates and taxes thereon that are current on the date of the opening of bids shall be considered applicable to all items subject to transportation charges thereunder. If such rates or taxes are thereafter increased by public authority on any materials entering into and forming a part of the Contract, an amount equal to the sum of all such increases, when evidenced by receipted common carrier bills, will be paid the Contractor by the Department. Requests for such payments shall be made not later than 60 days after final acceptance. If after the date of the opening of bids such rates or taxes are reduced by public authority on any materials entering into and forming a part of the Contract, an amount equal to the sum of all such decreases, when evidenced by receipted common carrier bills, will be deducted by the Department from the monies due the Contractor for the work performed under the Contract.

The carrier rates for petroleum tank truck carriers, as defined in the *Code of Virginia*, that are in effect on the date of the opening of bids for the project shall be considered effective for at least one year after that date. After one year from that date, the Department will pay the Contractor additional compensation equal to the cost of any carrier rate increases, subject to a maximum of eight percent of the original carrier rate for any materials ordered, delivered, and actually incorporated into the work after the one year period. However, the Contractor shall advise the Engineer in writing of his intent to request additional compensation attributable to carrier rate changes at the time of occurrence and shall submit receipted carrier bills and all relative information concerning the original and current carrier rates as they pertain to the project. If carrier rates are decreased after the one year period, the Department will deduct from monies due the Contractor an amount equal to the cost of any carrier rate decreases, subject to a maximum of eight percent of the original carrier rate, for any materials ordered, delivered, and actually incorporated into the work, based on receipted carrier bills that shall be furnished by the Contractor. On each succeeding year of the Contract, a maximum difference of eight percent of the original rate will be considered for increases or decreases in compensation under these terms and conditions.

Except for the aforementioned carriers, additional compensation attributable to changes in hauling rates of other contract carriers will not be allowed.

109.07—Eliminated Items

If any item in the Contract is determined to be unnecessary for the proper completion of the work contracted, the Department may, upon written notice to the Contractor, eliminate such item from the Contract. Payment will not be made for such item except that the Contractor will be compensated for the actual cost of any work performed for the installation of such item and the net cost of materials purchased, including freight and tax costs, as evidenced by invoice. No additional compensation will be made for overhead or anticipated profit.

109.08—Partial Payments**(a) General**

Partial payments will be based on a monthly progress estimate consisting of approximate quantities and value of work performed as determined by the Engineer. When the method of measurement for a contract item is in units of each or lump sum, the value of work accomplished for partial payment will be determined on a pro rata basis. Partial payments will be made once each month for the work performed in accordance with the contract requirements. The Contractor will be given the opportunity to review the monthly progress estimate prior to each partial payment. Upon final acceptance, one last monthly estimate will be prepared and any additional payment due will be vouchered for payment.

The monthly progress estimates will be prepared in accordance with the following schedule:

1. **Contractor companies whose name begins with the letter A through F:** The monthly progress estimate will be prepared on the 4th day of each month, beginning on the first 4th day following the date of the Contract execution, and on the same day of the succeeding months as the work progresses.
2. **Contractor companies whose name begins with the letter G through P:** The monthly progress estimate will be prepared on the 11th day of each month, beginning on the first 11th day following the date of the Contract execution, and on the same day of the succeeding months as the work progresses.
3. **Contractor companies whose name begins with the letter Q through Z:** The monthly progress estimate will be prepared on the 20th day of each month, beginning on the first 20th day following the date of the Contract execution, and on the same day of the succeeding months as the work progresses.

For contracts without a payment bond, the Contractor shall submit to the Engineer a letter from each materials supplier and subcontractor involved stating that the Contractor has paid or made satisfactory arrangements for settling all bills for materials and subcontracted work that was paid on the previous month's progress estimate. The Department will use the source of supply letter and approved subletting request to verify that certifications have been received for work that was paid on the previous monthly estimate. The Contractor shall furnish these and other certificates as are required as a prerequisite to the issuance of payment for the current monthly estimate.

The Department may withhold the payment of any partial or final estimate voucher or any sum(s) thereof from such vouchers if the Contractor fails to make payment promptly to all

persons supplying equipment, tools, or materials; for any labor he uses in the prosecution of the contract work.

(b) **Payment To Sub-Contractors**

Upon Department payment of the subcontractor's portion of the work as shown on the monthly progress estimate and the receipt of payment by the Contractor for such work, the Contractor shall make compensation in full to the subcontractor. For the purposes of this Section, payment of the subcontractor's portion of the work shall mean that payment has been issued for that portion of the work that was identified on the monthly progress estimate for which the subcontractor has performed service.

The Contractor shall make payment in full for the portion of the work identified on the monthly progress estimate to the subcontractor who performed such work within seven days of the receipt of payment from the Department in accordance with the requirements of this Section. If the Contractor withholds any funds as part of his contract with the subcontractor to ensure satisfactory compliance and completion and the subcontractor achieves satisfactory compliance and completion as verified by payment from the Department to the Contractor, the Contractor shall make full payment to the subcontractor within seven days.

If the Contractor fails to make payment to the subcontractor within the time frame specified herein, the subcontractor shall notify the Engineer and the Contractor's bonding company in writing. The Bonding Company shall be responsible for insuring payment in accordance with the requirements of this Section and Section 107.01.

(c) **Retainage**

If during the Engineer's monthly review of the Contractor's progress, the Engineer determines the Contractor's progress is unsatisfactory in accordance with the provisions of Section 108.03 or other contract specific criteria, the Engineer will send a notice of unsatisfactory progress to the Contractor advising him of such a determination. In addition, this notification will also advise the Contractor that 5 percent retainage of the monthly progress estimate is being withheld and will continue to be withheld for each month the Contractor's actual progress is determined to be unsatisfactory relative to the criteria stated herein..

When the Engineer determines that the Contractor's progress is considered satisfactory in accordance with these requirements, the 5 percent retainage previously withheld because of unsatisfactory progress will be released in the next monthly progress estimate and the remaining monthly progress estimates payments will be made in full provided satisfactory progress continues to be made.

109.09—Payment for Material on Hand

When requested in writing by the Contractor, payment allowances may be made for material secured for use on the project. Such material payments will be for only those actual quantities identified in the contract, approved work orders, or otherwise documented as required to complete the project and shall be in accordance with the following terms and conditions:

- (a) **Structural Units:** An allowance of 100 percent of the cost to the Contractor for structural steel materials for fabrication not to exceed 60 percent of the contract price may be made

when such material is delivered to the fabricator and has been adequately identified for exclusive use on the project. An allowance of 100 percent of the cost to the Contractor for superstructure units, not to exceed 90 percent of the contract price, may be made when they have been fabricated. Prior to the granting of such allowances, the structural steel materials and fabricated units shall have been tested or certified and found acceptable to the Department and shall have been stored in accordance with the requirements specified herein. Allowances will be based on invoices or bills, as approved by the Engineer and will be subject to the retainage requirements of Section 109.08.

- (b) **Other Materials:** For reinforcing steel, aggregate, pipe, guardrail, signs and sign assemblies, and other nonperishable material, an allowance of 100 percent of the cost to the Contractor for materials, not to exceed 90 percent of the contract price, may be made when such material is delivered and stockpiled or stored in accordance with the requirements specified herein. Prior to the granting of such allowances, the material shall have been tested and found acceptable to the Department. Allowances will be based on invoices or bills, as approved by the Engineer and will be subject to the retainage provisions of Section 109.08.
- (c) **Excluded Items:** No allowance will be made for cement, seed, plants, fertilizer, and other perishable material. and fuels, form lumber, falsework, temporary structures, or other work that will not become an integral part of the finished construction.
- (d) **Storage:** Material for which payment allowance is requested shall be stored in an approved manner in areas where damage is not likely to occur. If any of the stored materials are lost or become damaged, the Contractor shall repair or replace them. If payment allowance has been made prior to such damage or loss, the amount so allowed or a proportionate part thereof will be deducted from the next progress estimate payment and withheld until satisfactory repairs or replacement has been made.

When it is determined to be impractical to store materials within the limits of the project, the Engineer may approve storage on private property or, for structural units, on the manufacturer or fabricator's yard. Requests for payment allowance for such material shall be accompanied by a release from the owner or tenant of such property or yard agreeing to permit the removal of the materials from the property without cost to the Commonwealth.

- (e) **Materials Inventory:** If the Contractor requests a payment allowance for properly stored material, he shall submit a certified and itemized inventory statement to the Engineer no earlier than five days and no later than two days prior to the progress estimate date. The statement shall be submitted on forms furnished by the Department and shall be accompanied by invoices or other documents that will verify the material's cost. Following the initial submission, the Contractor shall submit to the Engineer a monthly-certified update of the itemized inventory statement within the same time frame. The updated inventory statement shall show additional materials received and stored with invoices or other documents and shall list materials removed from storage since the last certified inventory statement, with appropriate cost data reflecting the change in the inventory. If the Contractor fails to submit the monthly-certified update within the specified time frame, the Engineer will deduct the full amount of the previous statement from the progress estimate.

At the conclusion of the project, the cost of material remaining in storage for which payment allowance has been made will be deducted from the progress estimate.

109.10—Final Payment

When final acceptance has been duly made by the Engineer as provided for in Section 108.09 the Engineer will prepare the final statement of the quantities of the items of work performed. Thereafter, the Contractor will be afforded 10 days in which to review the final estimate before payment. The time may be extended by mutual agreement, and the extension added to the 90-day criteria set forth within this Section.

Prior partial estimates and payments shall be subject to correction in the final estimate and payment.

For Contracts not requiring a payment bond, the Contractor shall certify to the Department that he has paid or made satisfactory arrangements for settling all bills for materials, labor, equipment, supplies, and other items entering into or used on the work and shall furnish other certificates as are required by the Department as a prerequisite to the issuance of final payment.

Failure by the Contractor to provide required information and certifications will extend the 90-day period for final payment by the number of days equivalent to the delay attributable to the Contractor.

Upon review of the final estimate by the Contractor and approval by the Engineer, the Contractor will be paid the entire sum due after previous payments are deducted and other amounts are retained or deducted under the provisions of the Contract. Final payment will become due within 90 calendar days after final acceptance.

Upon written request from the Contractor, annual interest will be paid on the balance that has not been paid due to the fault of the Department within 90 calendar days after final acceptance. The rate of interest will be the base rate on corporate loans (prime rate) at large U.S. money center commercial banks as reported daily in *The Wall Street Journal*. When a split rate is published, the lower of the two rates shall be used. The rate effective on the 91st day following final acceptance will be applicable throughout the period of time for which interest is paid. However, in no event shall the rate of interest paid exceed the rate of interest established pursuant to the *Code of Virginia*, as amended. The period subject to payment of interest will begin on the 91st calendar day after final acceptance and will extend through the date of the payment of the final estimate.

When the payment date is delayed beyond the 90-day period by the fault of the Contractor and monies are due the Commonwealth the Contractor will be assessed annual interest on the balance due the Commonwealth for the time delay attributable to the Contractor. The rate of interest will be determined as specified hereinbefore.

Monies resulting from the final estimate and owed to the Commonwealth will become due and payable within 30 days of receipt by the Contractor of a certified letter giving notification of the amount owed. The Contractor will be assessed annual interest at the rate determined as specified within this Section for any balance that remains unpaid after 37 days from receipt of the letter.

After final acceptance and prior to final payment, the Contractor may request reimbursement for additional performance and payment bond premiums, but only to the extent that the final contract amount exceeds the original contract amount. If the Contractor requests reimbursement on such additional bond premiums the Contractor shall submit to the Department a written request for reimbursement, together with a notarized statement from the surety, or its agent that certifies the Contractor's actual bond premium rate for any increase in the amended contract amount above the original contract amount. Such request shall also contain the Contractor's calculation of the additional premium requested for reimbursement as verified by the surety or its agent.

109.10

Upon submission of such request from the Contractor, the Department will calculate the additional bond premium payment due the Contractor by multiplying the difference between the final contract amount, including all work orders, overruns, and adjustments, and the original contract amount, times the percentage bond premium rate provided by the Contractor and certified by the surety or its agent. The additional premium amount will be paid to the Contractor on the final estimate.

**Division II
MATERIALS**

SECTION 200—GENERAL

200.01—Description

These specifications cover general sampling and testing procedures, certifications for aggregate acceptance, and technicians and batchers for asphalt and hydraulic cement concrete.

200.02—Conformance with Specifications

Materials shall conform to these specifications in accordance with the requirements of Section 106.06. Whenever a reference to a material is followed by a reference to a specification, the material shall conform to the referenced specification.

Material that is required to conform to these specifications shall not be used until it has been approved by the Engineer.

Where maximum and minimum limits are given for a characteristic of a material, material whose specified characteristic approximates the mean value shall be furnished. The specified limits shall not be exceeded.

When a material is fabricated of or treated with another material or when any combination of materials is assembled to form a product, the failure of any component to comply with the applicable specification shall be sufficient cause for rejection of the whole unless the combination of components will produce a product satisfactory to the Engineer.

If the Contractor desires to substitute another material for that specified, he shall submit proof that the substitute material is equal in all respects to the material specified. Proof shall be in the form of specifications for the proposed substitution that may be readily compared with the specifications for the original material.

200.03—General Sampling and Testing Procedures

Materials shall be tested in accordance with the requirements of standard AASHTO, ASTM, or federal methods or methods devised by the Department as specified in the applicable specifications or as approved by the Engineer. At the discretion of the Engineer, the Contractor may furnish a certification of conformity from the manufacturer in lieu of testing.

The Engineer reserves the right to retest any material that has previously been tested or accepted on certification and reject that material if it is found to be defective.

The Department has developed test methods for the evaluation of certain materials or their properties. These test methods are identified by the prefix *VTM* (Virginia Test Method) followed by a number that will identify the specific VTM to be used. Copies of the Department's test methods may be obtained from the Department's Materials Division.

Sampling of materials shall be performed in accordance with the standard methods of the Department. When required, samples submitted to the Department's laboratory shall be accompanied by an MSDS. Failure by the Contractor to submit an MSDS will be cause for rejection of the material.

When a material is to be tested prior to delivery to the project, the Contractor shall furnish complete identification of the material and its specific intended use in the proposed construction, including references to the plans or specifications calling for the material.

Material will be inspected at the original or intermediate source of supply whenever it is economically advantageous to the Department. This inspection does not relieve the Contractor of the responsibility to furnish materials that conform to the specifications. The Department’s representative shall have ready access to all parts of any processing plant furnishing material for a project. Access for sampling and inspecting materials or plant equipment shall include secure, sturdy platforms conforming to local, state, and federal safety regulations.

The Department may discontinue the use of a plant laboratory for acceptance testing in the event of a mechanical malfunction of the laboratory equipment and in cases of emergency involving plant inspection personnel. In such event, acceptance testing will be performed at the district or central office laboratory until the malfunction or emergency has been satisfactorily corrected or resolved.

200.04—Acceptance Procedures for Aggregates

Aggregates conforming to the requirements of Section 207 (for Type I) and Section 208 will be accepted under a quality assurance program that uses statistical concepts. Aggregate materials shall conform to such requirements prior to the addition of admixtures.

Acceptance procedures for other aggregates shall be in accordance with the requirements of an approved production control plan conforming to the policies of the Department with regard to sampling and testing. Shipments of aggregates accepted under such a production control plan shall be accompanied by the following certification:

Aggregate Certification

Aggregate shipped under this certification has been tested and conforms to VDOT’s requirements.

Signature and Title

The certification may be printed or stamped on the delivery ticket or affixed by a gummed label thereto. The certification shall be signed by an authorized representative of the aggregate supplier and given to the Engineer upon delivery of the aggregate.

The No. 10 sieve shall be the dividing sieve for soils, select material, aggregate subbase material, and aggregate base material. The No. 8 sieve shall be the dividing sieve for asphalt concrete aggregates. That portion of the total aggregate retained on the sieves is defined as *coarse aggregate*, and that portion passing the sieves is defined as *fine aggregate*. Soundness tests will be performed in accordance with the requirements of AASHTO T104 without regard to these definitions of fine and coarse aggregate. Fine and coarse aggregates for hydraulic cement concrete are distinguishable by their conformity to the series of grading requirements specified in Section 202 and Section 203, respectively.

The term *nonpolishing aggregate* shall mean aggregate that the Department has determined will result in a surface of acceptable skid resistance when it is used and exposed as part of a wearing surface. The Department reserves the right to evaluate and determine the acceptability of polishing characteristics of aggregate proposed for use in pavement surfaces.

Crushed glass may be used for construction in drainage, embankment and backfilling applications, except for undercutting and foundation support for bridges, abutments, retaining walls and box culverts. The substitution of crushed glass will be permissive and limited to applications using material of size 3/8 inch and smaller where permitted for use in the Specifications.

200.05—Handling and Storing Aggregates

Stockpiles of aggregate shall be constructed on areas that are hard, well drained, and denuded of vegetation. The different sizes and kinds of aggregates shall be kept separate during handling and storage and until batched. Care shall be taken to prevent segregation of coarse and fine particles during handling and storing.

Aggregates placed directly on the ground shall not be removed from the stockpiles within 1 foot of the ground until final cleanup, and then only clean aggregate shall be used.

200.06—Technician and Batchers Certification

Certification for technicians and batchers will be awarded by the Department upon a candidate's satisfactory completion of an examination.

- (a) **Central Mix Aggregate Technician:** A Central Mix Aggregate Technician designs and makes necessary adjustments in job mixtures at the plant based on an analysis of the specified material. The technician also samples materials and conducts any tests necessary to put the plant into operation and produce a mixture in accordance with the applicable Specifications.
- (b) **Asphalt Plant Technician:** An Asphalt Plant Technician samples material and is capable of conducting any tests necessary to put the plant into operation.
- (c) **Concrete Plant Technician:** A Concrete Plant Technician performs necessary adjustments in the proportioning of material used to produce the specified concrete mixtures.
- (d) **Concrete Batchers:** A Concrete Batchers performs the batching operation. The batchers implements adjustments only at the direction of a certified Concrete Plant Technician unless the batchers's certification authorizes otherwise.
- (e) **Asphalt Field Technician:** An Asphalt Field Technician inspects asphalt concrete placement in accordance with applicable requirements.
- (f) **Concrete Field Technician:** A Concrete Field Technician provides quality control of placement operations for hydraulic cement concrete in accordance with applicable requirements.
- (g) **Asphalt Mix Design Technician:** An Asphalt Mix Design Technician is responsible for designing and adjusting mixes as needed, reviewing and approving all test results, having direct communication with the plant for making recommended adjustments and is capable of conducting any tests necessary to put the plant into operation.

- (h) **Aggregate Properties Technician:** An Aggregate Properties Technician conducts all aggregate tests on aggregate used in asphalt concrete in accordance with applicable requirements
- (i) **Slurry Surfacing Technician:** A Slurry Surfacing Technician inspects the placement of emulsified asphalt slurry seal and latex modified emulsion treatment (Micro-surfacing) in accordance with applicable requirements.
- (j) **Surface Treatment Technician:** A Surface Treatment Technician inspects the placement of single seal and modified (blotted) seal coats in accordance with applicable requirements.

SECTION 201—MINERAL FILLER

201.01—Description

These specifications cover inorganic material such as lime or fly ash, usually of very fine grading, added to soil or asphalt to produce a desired effect.

201.02—Detail Requirements

Mineral filler shall conform to the requirements of AASHTO M17. Tests will be performed in accordance with AASHTO T37.

SECTION 202—FINE AGGREGATE

202.01—Description

These specifications cover material for use as fine aggregate in hydraulic cement concrete, mortar, asphalt concrete, and asphalt surface treatments.

202.02—Materials

Fine aggregate is classified herein in accordance with its occurrence or method of manufacture as natural sand or stone sand. Natural sand shall consist of grains of hard, sound material, predominantly quartz, occurring in natural deposits or in loosely bound deposits, such as sandstone conglomerate. Stone sand shall consist of sound crushed particles of approved Grade A stone, essentially free from flat or elongated pieces, with sharp edges and corners removed.

Fine aggregates for use in hydraulic cement concrete that are obtained from more than one source shall not be used alternately or mixed without the consent of the Engineer.

TABLE II-1
Fine Aggregate

Grading	3/8 in.	Amounts Finer Than Each Laboratory Sieve (Square Opening) (% by Weight)						
		No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
A	Min. 100	95-100	80-100	50-85	25-60	5-30	Max. 10	
B	Min. 100	94-100					Max. 10	
C	Min. 100	94-100				Max. 25		

202.03—Detail Requirements

- (a) **Grading:** Grading shall conform to the requirements of Table II-1. Tests will be performed in accordance with the requirements of AASHTO T27.
- (b) **Soundness:** Soundness shall conform to the requirements of Table II-2. Tests will be performed in accordance with the requirements of AASHTO T103 or T104.
- (c) **Organic Impurities:** When fine aggregate is to be used in hydraulic cement concrete, the percentage of organic impurities shall conform to the requirements of AASHTO T21; however, material producing a darker color than that specified in AASHTO T21 may be accepted in accordance with the requirements of AASHTO M6.
- (d) **Void Content:** Void content will be tested in accordance with the requirements of VTM-5.
- (e) **Deleterious Material:** The amount of deleterious material in sands shall be not more than the following:

Material	% by Weight	AASHTO Test Method
Clay lumps	0.25	T112
Shale, mica, coated grains, soft or flaky particles	1.0	T113
Organic material	0	T21
Total material passing No. 200 sieve by washing ¹		T11 and T27
For use in concrete subject to abrasion	3	
For other concrete	5	

¹In the case of stone sand, if the material passing the No. 200 sieve is dust of fracture, essentially free from clay and shale, the percentages shown for use in concrete subject to abrasion and in other concrete may be increased to 5.0 percent and 7.0 percent, respectively.

TABLE II-2
Soundness

Use	Max. Soundness Loss (%)	
	Magnesium Sulphate (5 Cycles)	Freeze and Thaw (100 Cycles)
Hydraulic cement concrete	18	8
Asphalt concrete surfaces and surface treatments	25	15
Asphalt concrete bases	30	15

SECTION 203—COARSE AGGREGATE

203.01—Description

These specifications cover material for use as coarse aggregate in hydraulic cement concrete, asphalt concrete, asphalt surface treatments, and drainage.

203.02—Materials

Coarse aggregate shall consist of crushed stone, crushed slag, crushed or uncrushed gravel with clean, hard, tough, and durable pieces free from adherent coatings and deleterious amounts of friable, thin, elongated, or laminated pieces; soluble salts; or organic materials.

- (a) **Crushed hydraulic cement concrete** will be permitted for use as a coarse aggregate provided it conforms to the physical requirements specified herein and shows no adverse chemical reaction. Crushed hydraulic cement concrete will not be permitted in the following: (1) reinforced cement concrete, (2) in combination with other materials in contact with geotextile fabric when such fabric is used as a drainage item, and (3) in backfill or bedding for perforated pipe.
- (b) **Crushed gravel** shall consist of particles of which at least 80 percent by weight shall have at least one face fractured by artificial crushing. Tests will be performed in accordance with the requirements of VTM-15.
- (c) **Blast furnace slag** shall be relatively free from foreign minerals and glassy or spongy pieces. It shall weigh at least 70 pounds per cubic foot, dry rodded, for size No. 68 and smaller and at least 65 pounds per cubic foot, dry rodded, for larger sizes. Tests will be performed in accordance with the requirements of AASHTO T19. When used in asphalt surface treatments, blast furnace slag shall contain not more than 10 percent nonporous material and shall have an absorption of at least 3 percent. Tests will be performed in accordance with the requirements of AASHTO T85.
- (d) **Crushed glass** shall consist of particles of curbside-collected or waste glass. It shall be free from sources of glass that include automotive glass, lead crystal, TV monitors, lighting fixtures and electronics applications. Non-glassy material associated with curbside collection (paper, capping materials, etc.), excluding fragments of broken ceramics and pottery, shall be limited to 5 percent by weight using a gravimetric determination, and including loss on ignition performed in accordance with the requirements of ASTM D2974. One hundred percent of the crushed glass shall pass the 9.5 mm (3/8 inch) sieve with less than 5 percent passing the No. 200 sieve. Crushed glass shall not be used in hydraulic cement concrete, asphalt, base/subbase, or exposed shoulder applications.

203.03—Detail Requirements

- (a) **Grading:** Open-graded aggregates shall conform to the requirements of Table II-3. Tests will be performed in accordance with the requirements of AASHTO T27.

TABLE II-3
Sizes of Open-Graded Coarse Aggregates

Va. Size	Amounts Finer Than Each Laboratory Sieve (Square Openings) (% by Weight)															
	No.	4 in.	3 1/2 in.	3 in.	2 1/2 in.	2 in.	1 1/2 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	No. 4	No. 8	No. 16	No. 50	No. 100
1	Min. 100	90-100			25-60		Max. 15		Max. 5							
2			Min. 100		90-100	35-70	Max. 15		Max. 5							
3					Min. 100	90-100	35-70	0-15		Max. 5						
357					Min. 100	95-100		35-70		10-30		Max. 5				
5					Min. 100	90-100		90-100	20-55	Max. 10	Max. 5					
56					Min. 100	90-100		90-100	40-85	10-40	Max. 15	Max. 5				
57					Min. 100	95-100		95-100	25-60			Max. 10	Max. 5			
67							Min. 100	90-100		90-100	20-55	Max. 10	Max. 5			
68							Min. 100	90-100		90-100	30-65	5-25	Max. 10	Max. 5		
7								Min. 100	Min. 100	90-100	40-70	Max. 15	Max. 5			
78								Min. 100	Min. 100	90-100	40-75	5-25	Max. 10	Max. 5		
8										Min. 100	85-100	10-30	Max. 10	Max. 5		
8P										Min. 100	75-100	5-30	Max. 5			
9											Min. 100	85-100	10-40	Max. 10	Max. 5	
10												Min. 100	85-100			10-30

TABLE II-4
Soundness

Use	Max. Soundness Loss (%)	
	Magnesium Sulphate (5 Cycles)	Freeze and Thaw (100 Cycles)
Hydraulic cement concrete	12	5
Asphalt surface courses	15	6
Asphalt and aggregate bases	20	7
Select material (Type I) and subbase	30	12

TABLE II-5
Abrasion

Use	Max. Los Angeles Abrasion Loss (%)	
	100 Rev.	500 Rev.
Grade A stone	9	40
Grade B stone	12	45
Grade C stone	14	50
Slag	12	45
Gravel	12	45

- (b) **Soundness:** Soundness shall conform to the requirements of Table II-4. Tests will be performed in accordance with the requirements of AASHTO T103 or T104. The requirement for soundness test for crushed glass is waived due to its preclusion from the applications shown in Table II-4.
- (c) **Abrasion Loss:** Abrasion loss shall conform to the requirements of Table II-5. Tests will be performed in accordance with the requirements of AASHTO T96 on aggregate with a grading the most nearly identical with the grading to be used in the work.
- (d) **Deleterious Material:** The amount of deleterious material shall be not more than the following:

Material	% by Weight	AASHTO Test Method
Coal and lignite	0.25	T113
Clay lumps	0.25	T112
Material passing No. 200 sieve by washing ¹	1.00	T11

¹When the material passing the No. 200 sieve by washing is dust of fracture, the percentage of deleterious material may be increased to 1.50 percent.

- (e) **Flat and Elongated Particles:** Coarse aggregate to be used as a riding surface during construction activities or as the riding surface after construction shall contain not more than 30 percent by mass of aggregate particles retained on and above the 3/8-inch sieve having a maximum to minimum dimensional ratio greater than 5 as determined in accordance with the requirements of ASTM D4791.

SECTION 204—STONE FOR MASONRY, RIPRAP, POROUS BACKFILL, AND GABIONS

204.01—Description

These specifications cover aggregate materials used to protect ground slopes from erosion or wave action and those used for drainage, generally behind a backwall or abutment.

204.02—Detail Requirements

- (a) **Stone for rubble or mortar rubble masonry** shall be sound, durable, and free from seams, cracks, and other structural defects and shall be minimum Grade C stone free from rounded, worn, or weathered surfaces.
- (b) **Stone for riprap and bedding** shall be sound, durable, and free from seams, cracks, and other structural defects. Riprap stone and bedding exposed to the wave action of water shall be of igneous or metamorphic origin. Riprap bedding shall be crushed stone, minimum Grade B.
- (c) **Porous backfill** shall be aggregate size No. 78 or No. 8, a minimum Grade B. Crushed glass meeting the gradation requirements specified in Section 203.02(d) of the Specifications can be directly substituted for size No. 78 and 8 aggregates.
- (d) **Gabion stone** shall be durable and free from seams and cracks. Weathered stone shall not be used. Stone shall weigh between 4 and 30 pounds except that approximately 5 percent of the individual stones may weigh less than 4 or more than 30 pounds. At least 50 percent of the stone shall weigh more than 10 pounds.

SECTION 205—CRUSHER RUN AGGREGATE

205.01—Description

These specifications cover crushed aggregate used for backfilling and bedding pipe and box culverts, maintaining traffic, and repairing and constructing all-weather private access pavements.

205.02—Materials

Crusher run aggregate shall be crushed from stone, slag, or gravel and shall contain all of the sizes produced when the original aggregate is reduced through a series of crushers to the maximum size specified. It shall be essentially free from deleterious substances in accordance with the requirements of Section 203.

- (a) **Crushed hydraulic cement concrete** will be permitted for use as crusher run aggregate provided it conforms to the physical requirements of Section 203 and shows no adverse

chemical reaction. It shall not be used in a subsurface drainage application in combination with perforated pipe or as a base material where geotextile fabric is to be used.

- (b) **Crushed gravel** shall consist of particles of which at least 90 percent by weight of material retained on the No. 10 sieve shall have at least one face fractured by artificial crushing. Tests will be performed in accordance with the requirements of VTM-15.
- (c) **Crushed glass** will be permitted for use as crusher run aggregate provided it conforms to the physical requirements of Section 203.02(d) of the Specifications. Crushed glass having the gradation specified in Section 203.02(d) of the Specifications can be directly substituted for size No. 25 and 26 aggregates in pipe bedding and backfilling applications only.

205.03—Detail Requirements

- (a) **Grading:** Grading shall conform to the following requirements when tested in accordance with the requirements of AASHTO T27:

Size No.	% by Weight of Materials Passing Sieve					
	2 1/2 in	2 in	1 1/2 in	1 in	3/4 in	No 4
24	Min. 100	95±5				32±18
25			Min. 100	95±5		32±18
26				Min. 100	95±5	38±22

- (b) **Atterberg Limits:** The liquid limit shall be not more than 25. The plasticity index shall be not more than 3. Tests will be performed in accordance with the requirements of VTM-7.
- (c) **Soundness:** Soundness shall conform to the requirements of Table II-4. Tests will be performed in accordance with the requirements of AASHTO T103 or T104. The requirement for soundness test for crushed glass is waived due to its preclusion from the applications shown in Table II-4.
- (d) **Abrasion Loss:** Abrasion loss shall be not more than 45 percent. Tests will be performed in accordance with the requirements of AASHTO T96.
- (e) **Flat and Elongated Particles:** Crusher run aggregate to be used as a riding surface during construction activities or as the riding surface after construction shall contain not more than 30 percent by mass of aggregate particles retained on and above the 3/8-inch sieve having a maximum to minimum dimensional ratio greater than 5 as determined in accordance with the requirements of ASTM D4791.

SECTION 206—LIGHTWEIGHT AGGREGATE

206.01—Description

These specifications cover lightweight aggregate used in hydraulic cement concrete and asphalt surface treatment.

206.02—Detail Requirements

Lightweight aggregate shall consist of clay, shale, or slate expanded through a sintering or rotary kiln.

- (a) **Lightweight aggregate used in hydraulic cement concrete** shall conform to the requirements of AASHTO M195.
- (b) **Lightweight aggregate used for asphalt surface treatment** shall conform to the requirements of AASHTO M195 except that Sections 3, 6, and 8 will not apply. Grading shall conform to the requirements of Table II-3 except that the maximum percentage by weight of material passing the No. 8 sieve shall be 16 percent and passing the No. 16 sieve shall be 9 percent.

SECTION 207—SELECT MATERIAL**207.01—Description**

These specifications cover nonplastic material obtained from roadway cuts, borrow areas, or commercial sources used as foundation for subbase, shoulder surfacing, fill, backfill, or other specific purposes.

TABLE II-6
Design Range: Select Material, Type I

% by Weight of Material Passing Sieve					
3 in	2 in	No. 10	No. 40	No. 200	ASTM D4791 Flat & Elongated 5:1
100	95-100	25-55	16-30	4-14	30% max.

207.02—Detail Requirements

Select material shall consist of approved local or commercial materials free from roots, muck, and debris.

- (a) **Grading:**
 1. **Type I:** Grading for Type I shall conform to the job-mix formula selected from within the design range specified in Table II-6, subject to the applicable tolerances specified in Table II-7 when tested in accordance with the requirements of VTM- 25.
 2. **Type II and Type III:** Grading for Types II and III shall conform to the following when tested in accordance with the requirements of VTM-25:

% by Weight of Material Passing Sieve

Type	3 in	2 in	No. 200
II	Min. 100	Min. 100	Max. 25
III ¹			Max. 20

¹A maximum of 25 percent of material retained on the No. 200 sieve will be allowed for Type III if the liquid limit is less than 25 and the plasticity index is less than 6.

TABLE II-7
Process (P) and Range (R) Tolerance: Select Material, Type I

No. Test	Tolerance on Each Laboratory Sieve (%)										
	3 in		2 in		No. 10		No. 40		No. 200		
	P	R	P	R	P	R	P	R	P	R	
1	0.0		±4.0		±15.0		±10.0		±6.0		
2	0.0	0.0	±3.0	5.0	±10.5	18.5	±7.0	13.0	±4.0	8.5	
3	0.0	0.0	±2.5	5.5	±8.5	22.0	±5.5	15.0	±3.5	10.0	
4	0.0	0.0	±2.0	6.0	±7.5	23.5	±5.0	16.5	±3.0	10.5	
8	0.0	0.0	±1.5	7.0	±5.5	26.5	±3.0	18.5	±2.0	12.0	

(b) **Atterberg Limits:**

- Type I:** The mean of the Atterberg limits shall conform to the requirements in Table II-8 when tested in accordance with the requirements of VTM-7.
- Types II and III:** Atterberg limits shall conform to the following when tested in accordance with the requirements of VTM-7:

Type	Max. Liquid Limit	Max. Plasticity Index
II	30	9
III	30	9

- California Bearing Ratio (CBR):** Tests for CBR will be performed in accordance with the requirements of VTM-8 for conformance to the specified value.
- Soundness:** Soundness for Type 1 shall conform to the requirements of Table II-4. Tests will be performed in accordance with the requirements of AASHTO T103 or T104.
- Flat and Elongated Particles:** Select materials to be used as a riding surface during construction activities or as the riding surface after construction shall contain not more than 30 percent by mass of aggregate particles retained on and above the 3/8-inch sieve having a maximum to minimum dimensional ratio greater than 5 as determined in accordance with the requirements of ASTM D4791.
- Crushed glass** that conforms to the physical requirements set forth in the Specifications shall be limited to Type II and Type III applications to exclude those applications listed in Section 203.02(d) of the Specifications.

207.03—Job-Mix Formula for Select Material, Type I

The Contractor shall submit or shall have the supplier submit a job-mix formula for the Engineer's approval prior to starting work. The formula shall establish a single percentage of aggregate passing each required sieve size denoted in Table II-6 and shall be in effect until a modification is approved by the Engineer. If unsatisfactory results or other changed conditions make it necessary, the Contractor shall prepare and submit a new formula for the Engineer's approval.

207.04—Mixing

The Contractor shall provide a laboratory as specified in Section 106.07. Select material shall be produced at optimum moisture ± 2 percentage points.

The Contractor shall have a certified Central Mix Aggregate Technician present at the plant during initial setup and subsequent production.

TABLE II-8
Atterberg Limits: Select Material Type I

No. Tests	Max. Liquid Limit	Max. Plasticity Index
1	25.0	6.0
2	23.9	5.4
3	23.2	5.1
4	23.0	5.0
8	22.4	4.7

207.05—Acceptance of Select Material, Type I

Sampling and testing for determination of grading and Atterberg limits shall be performed by the Contractor. The Contractor shall provide the Department copies of test results on forms furnished by the Department and shall maintain appropriate, current quality control charts. The Department will perform independent monitor tests. If there is a statistically significant difference between the two sets of results, an investigation will be made to determine the reason for the difference. If it is determined that the material does not conform to the requirements of the Contract, the material will be rejected or a payment adjustment will be made in accordance with the requirements of Section 207.07.

Determination of grading and Atterberg limits will be based on a mean of the results of tests performed on four samples taken in a stratified random manner for each 2,000-ton lot. Lots of 4,000 tons may be used when the normal daily production of the source from which the material is being obtained is more than 2,000 tons. If visual examination reveals that the material is obviously contaminated or segregated, the material will be rejected without additional sampling or testing. If it is necessary to determine the grading and Atterberg limits of the material in an individual location, one sample taken from the material in question will be tested and the results will be compared to the job-mix formula with the tolerances specified in Table II-7 and Table II-8 for one test. The results obtained will apply only to the material in question.

A lot will be considered acceptable for grading if the mean of the results falls within the allowed deviation from the job-mix formula and the difference between the maximum and minimum results does not exceed the range values specified in Table II-7.

A lot will be considered acceptable for Atterberg limits if the mean of the test results is less than the maximum allowed for the liquid limit and plasticity index values specified in Table II-8.

If the liquid limit exceeds 30 or the plasticity index exceeds 9 on any individual sample, that portion of the lot from which the sample was taken will be considered a separate part of the lot and shall be removed from the road.

If the Contract specifies less than 2,000 tons of material, the amount of material necessary to complete the last lot is less than 2,000 tons (or 4,000 tons, if applicable), the job-mix formula is modified within a lot, or a portion of the lot is rejected on the basis of individual test results, the mean results of the tests on the samples taken will be compared to the job-mix formula with the applicable process tolerances specified in Table II-7 and Table II-8 for the number of tests performed.

207.06—Referee System for Select Material, Type I

If the test results obtained for one of the four samples or the mean of the four samples tested to evaluate a particular lot is questionable, the referee system as specified in Section 208.07 will be applied except that the final mean results will be compared to the job-mix formula with the tolerances given in Table II-7 and Table II-8 for the mean of eight tests.

207.07—Payment Adjustment System for Select Material, Type I

If a lot of material does not conform to the acceptance requirements stated herein, adjustment points, determined as follows, will be applied for each 1 percent or part thereof that the grading or Atterberg limits are outside the job-mix formula with the tolerances given in Table II-7 and Table II-8.

Sieve Size	Adjustment Points	
	Process	Range
3-in	1	1
2-in	1	1
No. 10	1	1
No. 40	3	3
No. 200	5	5

Atterberg Limits	Adjustment Points
Liquid limit	3
Plasticity index	7

If the total adjustment (excluding the range adjustment) for the lot is more than 25 points, the failing material shall be removed from the road. If the total adjustment (excluding the range adjustment) is 25 points or less and the Contractor does not elect to remove and replace the material, the contract unit

price for the material will be reduced by 1 percent for each adjustment point. The total adjustment will be applied to the tonnage represented by the sample(s).

SECTION 208—SUBBASE AND AGGREGATE BASE MATERIAL

208.01—Description

These specifications cover material used to form a foundation for base or surface pavement.

TABLE II-9
Design Range for Dense-Graded Aggregates

Size No.	Amounts Finer Than Each Laboratory Sieve (Square Openings ¹)						ASTM D4791 Flat & Elongated 5:1
	2 in	1 in	3/8 in	No. 10	No. 40	No. 200	
21A	100	94–100	63–72	32–41	14–24	6–12	30% max.
21B	100	85–95	50–69	20–36	9–19	4–7	30% max.
22	—	100	62–78	39–56	23–32	8–12	30% max.

¹In inches, except where otherwise indicated. Numbered sieves are those of the U.S. Standard Sieve Series.

208.02—Materials

- (a) **Subbase material** shall consist of mixtures of natural or crushed gravel, crushed stone or slag, and natural or crushed sand, with or without soil mortar.
- (b) **Aggregate base material** will be designated as Type I or Type II as follows: **Type I** shall consist of crushed stone, crushed slag, or crushed gravel, with or without soil mortar or other admixtures. Crushed gravel shall consist of particles of which at least 90 percent by weight of the material retained on the No. 10 sieve shall have at least one face fractured by artificial crushing. **Type II** shall consist of gravel, stone, or slag screenings; fine aggregate and crushed coarse aggregate; sand-clay-gravel mixtures; or any combination of these materials; with or without soil mortar or other admixtures.

208.03—Detail Requirements

- (a) **Grading:** Grading shall conform to the requirements of the job-mix formula selected from within the design range specified in Table II-9, subject to the applicable tolerances specified in Table II-10 when tested in accordance with the requirements of VTM-25.

TABLE II-10
Process Tolerances for Each Laboratory Sieve (%)

No. Tests	Top Size	1 in	3/4 in	3/8 in	No. 10	No. 40	No. 200
1	0.0	±10.0	±14.0	±19.0	±14.0	±8.0	±4.0
2	0.0	±7.1	±10.0	±13.6	±10.0	±5.7	±2.9
3	0.0	±5.6	±7.8	±10.6	±7.8	±4.4	±2.2
4	0.0	±5.0	±7.0	±9.5	±7.0	±4.0	±2.0
8	0.0	±3.6	±5.0	±6.8	±5.0	±2.9	±1.4

TABLE II-11
Atterberg Limits

Max. Liquid Limit		Max. Plasticity Index	
No. Tests	Subbase and Aggregate Base Type I and II	Subbase Sizes No. 21A, 22, and Aggregate Base Type II	Aggregate Base Type I and Subbase Size No. 19
1	25.0	6.0	3.0
2	23.9	5.4	2.4
3	23.2	5.1	2.1
4	23.0	5.0	2.0
8	22.4	4.7	1.7

- (b) **Atterberg Limits:** Atterberg limits shall conform to the requirements of Table II-11 when tested in accordance with the requirements of VTM-7.
- (c) **Soundness:** Soundness shall conform to the requirements of Table II-4 when tested in accordance with the requirements of AASHTO T103 or T104.
- (d) **Abrasion Loss:** Abrasion loss shall be not more than 45 percent when tested in accordance with the requirements of AASHTO T96.
- (e) **Optimum Moisture:** Material shall be produced at optimum moisture ± 2 percentage points.
- (f) **Admixtures:** Admixtures shall conform to the requirements of the applicable Specifications.
- (g) **Flat and Elongated Particles:** Subbase and aggregate base materials to be used as a riding surface during construction activities or as the riding surface after construction shall contain not more than 30 percent by mass of aggregate particles retained on and above the 3/8-inch sieve having a maximum to minimum dimensional ratio greater than 5 as determined in accordance with the requirements of ASTM D4791.

208.04—Job-Mix Formula

The Contractor shall submit, or shall have the source of supply submit, for the Engineer's approval, a job-mix formula for each mixture to be supplied for the project prior to starting work. The formula shall be within the design range specified in Table II-9. If unsatisfactory results or other conditions make it necessary, the Contractor shall prepare and submit a new job-mix formula for approval.

208.05—Mixing

Subbase or aggregate base materials shall be mixed in an approved central mixing plant of a pugmill or other mechanical type. Materials shall be blended prior to or during mechanical mixing in a manner than will ensure conformance to the specified requirements.

Preparation of subbase and aggregate base material will be subject to inspection at the plant. The Contractor shall provide a laboratory as specified in Section 106.07.

During the initial setup and subsequent production, the Contractor shall have a certified Central Mix Aggregate Technician present at the plant.

208.06—Acceptance

The Contractor shall provide the quality assurance necessary for the Engineer to determine conformance to the required grading and Atterberg limits of subbase and aggregate base material.

Sampling and testing for determination of grading and Atterberg limits shall be performed by the Contractor. The Contractor shall provide copies of test results to the Department on forms furnished by the Department and shall maintain appropriate current quality control charts. The Department will perform independent monitor tests at a laboratory of its choice. If there is a statistically significant difference between the two sets of results, an investigation will be made to determine the reason for the difference. If it is determined that the material does not conform to the requirements of the Contract, the material will be rejected or a payment adjustment will be made in accordance with the requirements of Section 208.08.

Determination of grading and Atterberg limits will be based on a mean of the results of tests performed on four samples taken in a stratified random manner from each 2,000-ton lot. Lots of 4,000 tons may be used when the normal daily production of the source from which the material being obtained is more than 2,000 tons. Unless otherwise approved, samples shall be obtained from the approximate center of truckloads of material. Any statistically acceptable method of randomization may be used to determine the time and location of the stratified random sample to be taken. The Department shall be advised of the method to be used prior to the beginning of production.

A lot will be considered acceptable for grading if the mean of the test results is within the deviation from the job-mix formula specified in Table II-10.

A lot will be considered acceptable for Atterberg limits if the mean of the test results is less than the maximum for the liquid limit and plasticity index specified in Table II-11.

If the liquid limit exceeds 30 or the plasticity index exceeds 6 for Type I base material or No. 19 sub-base material; or the plasticity index exceeds 9 for Type II base material or subbase materials No. 20,

21, 21A, 21B, or 22 on any individual sample; that portion of the lot from which the sample was taken will be considered a separate part of the lot and shall be removed from the road.

If either the amount of material in the lot is less than 2,000 tons (4,000 tons if applicable), the job-mix formula is modified within a lot, or a portion of the lot is rejected on the basis of individual test results, the mean test results of the samples taken will be compared to the job-mix formula with the tolerances given in Tables II-10 and II-11 for the number of tests performed.

If a visual examination reveals that material in any load is obviously contaminated or segregated, the load will be rejected without additional sampling or testing of the lot. If it is necessary to determine grading or Atterberg limits of material in an individual load, one sample (taken from the load) will be tested and the results compared to the job-mix formula with the tolerances given in Tables II-10 and II-11 for one test. Results obtained in the testing of a specific individual load will apply only to the load in question.

208.07—Referee System

If the test results obtained for one of the four samples taken to evaluate a particular lot are questionable, the Contractor may request that the results of the questionable sample be disregarded. The Contractor shall then perform tests on five additional samples taken from randomly selected locations in the roadway where the lot was placed. If the Engineer determines that one of the four test results is questionable, the Department will perform tests on five additional samples taken from randomly selected locations in the roadway where the lot was placed. The test results of the three original (unquestioned) samples will be averaged with the tests results of the five road samples, and the mean of the test values obtained for the eight samples will be compared to the job-mix formula with the tolerances specified in Table II-10 and Table II-11 for the mean of eight tests.

If the Contractor questions the mean of the four original test results obtained for a particular lot, he may request approval to perform additional testing of that lot. If the Contractor requests further tests, he shall sample and test the material in accordance with procedures approved by the Engineer. If the Engineer determines that the mean of the four original test results is questionable, the Department will perform additional testing of that lot. The test results of the original four samples will be averaged with the test results of the four additional samples taken from randomly selected locations in the roadway where the lot was placed, and the mean of test values obtained for the eight samples will be compared to the job-mix formula with the tolerances specified in Tables II-10 and II-11 for the mean result of eight tests.

If the mean of the test values obtained for the eight samples conforms to the requirements for the mean of the results of eight tests, the material will be considered acceptable; if the mean does not conform, the lot will be adjusted in accordance with the payment adjustment rate specified in Section 208.08.

The provisions of this Section will not be applicable to mixtures containing cement or other admixtures that alter the characteristics of the material.

208.08—Payment Adjustment System

If a lot of material does not conform to the acceptance requirements of Section 208.06, payment adjustment points will be determined as follows:

**Adjustment Points for Each 1% Grading Is Outside
Tolerance Permitted in Table II-10**

Sieve No.	
2 in	1
1 in	1
3/4 in	1
3/8 in	1
10	1
40	3
200	5

**Atterberg
Limits**

**Adjustment Points for Each 1% Atterberg Limits
Exceed Maximum Permitted in Table II-11**

Liquid limit	3
Plasticity index	7

If the total adjustment for the lot is more than 25 points, the failing material shall be removed from the road. If the total adjustment is 25 points or less and the Contractor does not elect to remove and replace the material, the unit price for the material will be reduced by 1 percent for each adjustment point. The adjustment will be applied to the tonnage represented by the sample(s).

The Contractor shall control the variability of his product in order to furnish a consistent, well-graded mixture. When the quantity of any one type of material furnished for a project exceeds 4,000 tons, the variability of the total quantity furnished will be determined on the basis of the standard deviation for each sieve size. If the standard deviation is within the limits specified in Table II-12, the contract unit price for the material will be adjusted as indicated hereinafter. Standard deviation computations will not be made separately on more than two job mixtures for the same type of material.

**TABLE II-12
Standard Deviation**

No. of Payment Adjustment Points for Each Sieve Size			
Sieve Size	1 Adjustment Point for Each Sieve Size	2 Adjustment Points for Each Sieve Size	3 Adjustment Points for Each Sieve Size
2 in	0.6-1.5	1.6-2.5	2.6-3.5
1 in	4.6-5.5	5.6-6.5	6.6-7.5
3/4 in	5.6-6.5	6.6-7.5	7.6-8.5
3/8 in	7.1-8.0	8.1-9.0	9.1-10.0
No. 10	5.6-6.5	6.6-7.5	7.5-8.5
No. 40	3.6-4.5	4.6-5.5	5.6-6.5
No. 200	3.1-4.0	4.1-5.0	5.1-6.0

The contract unit price will be reduced by 0.5 percent for each adjustment point applied for standard deviation.

The disposition of material having standard deviations larger than those specified in Table II-12 will be as determined by the Engineer.

SECTION 209—OPEN-GRADED SHOULDER MATERIAL

209.01—Description

These specifications cover the requirements for open-graded material used on roadway shoulders where designated.

209.02—Detail Requirements

Open-graded shoulder material shall be aggregate material No. 18 and shall consist of mixtures of natural or crushed gravel, crushed stone, or sand, without soil mortar.

- (a) **Grading:** Grading shall conform to the following when tested in accordance with the requirements of VTM-25:

% by Weight of Material Passing Sieve					
2 in	1 in	3/8 in	No. 10	No. 40	No. 200
100	90 ± 10	55 ± 15	20 ± 10	8 ± 5	3 ± 3

- (b) **Atterberg Limits:** Material shall be nonplastic, and the liquid limit shall be not more than 25 when tested in accordance with the requirements of VTM-7.
- (c) **Soundness:** Soundness shall conform to the requirements of Table II-7 for subbase material when tested in accordance with the requirements of AASHTO T103 or T104.
- (d) **Abrasion Loss:** Abrasion loss shall be not more than 45 percent when tested in accordance with the requirements of AASHTO T96.

209.03—Mixing

Pugmill mixing will not be required for aggregate shoulder material No. 18. The Contractor shall provide a laboratory as specified in Section 106.07.

SECTION 210—ASPHALT MATERIALS

210.01—Description

These specifications cover asphalt material consisting of asphalt, asphalt cement, asphalt cutback, or asphalt emulsion as defined in ASTM D8.

210.02—Materials

Asphalt material shall be homogeneous and shall conform to the following:

- (a) **Rapid curing and medium curing liquid asphalts used as surface treatments** shall contain a heat-stable additive conforming to the requirements of Section 211.
- (b) **Liquid asphalt material** will be tested for coating ability in accordance with the requirements of AASHTO T182, with the following modifications:
 - 1. Material that can coat 95 percent of a shady dolomite will be classified Type I.
 - 2. Material that can coat 95 percent of a siliceous gravel wetted with 2 percent water by weight will be classified Type II.
- (c) **Rapid curing cutback asphalts** shall conform to the requirements of AASHTO M81.
- (d) **Medium curing cutback asphalts** shall conform to the requirements of AASHTO M82.
- (e) **Cements** shall be viscosity graded and shall conform to the requirements of AASHTO M226, Table 2, except that the loss on heating shall be not greater than 1.0 for AC-5, 0.8 for AC-20, and 0.5 for all other grades.
- (f) **Emulsions** shall conform to the requirements of AASHTO M208 and shall be Type I as specified herein except that CRS-2 shall be Type II as specified herein. CRS-1h shall conform to the requirements of AASHTO M208 for CRS-1 except that the penetration shall be 40 to 110. Emulsions will be sampled and tested in accordance with the requirements of AASHTO T59 except that viscosity will be tested in accordance with the requirements of VTM-64.

210.03—Detail Requirements

- (a) **Shipping:** Shipments of asphalt material shall be made in transporting media that are free from contamination. Tank trucks or trailers shall be equipped with a sampling device approved by the Engineer. The device shall have an inside diameter of 1/2 to 1 inch and a gate valve or petcock. The device shall be built into the tank or the recirculating or discharge line so that a sample can be drawn during circulation or discharge.
- (b) **Storing:** Asphalt material to be stored shall be placed in storage tanks that are free from contamination.

210.04—Payment Adjustment System

If the material represented by any one sample does not conform to the requirements herein and the material is a pay item, the contract unit price for the item will be reduced by 4 percent for each property that does not conform to the Specifications for the quantity represented by the sample that was used on the project. Unused material represented by the failing sample will be rejected.

If the material represented by a failing sample was not a pay item, the material will be considered unacceptable and shall be subject to the requirements of Section 105.18 and Section 106.10.

SECTION 211—ASPHALT CONCRETE

211.01—Description

Asphalt concrete shall consist of a combination of mineral aggregate and asphalt material mixed mechanically in a plant specifically designed for such purpose.

An equivalent single-axle load (ESAL) will be established by the Engineer, and SUPERPAVE mix types may be specified as one of the types listed as follows:

Mix Type	Equivalent Single-Axle Load (ESAL) Range (millions)	Asphalt Performance Grade (PG)	Aggregate Nominal Maximum Size ¹
SM-9.0 A	0 to 3	64–22	3/8 in
SM-9.0 D	3 to 10	70–22	3/8 in
SM-9.0 E	Above 10	76–22	3/8 in
SM-9.5 A	0 to 3	64–22	3/8 in
SM-9.5 D	3 to 10	70–22	3/8 in
SM-9.5 E	Above 10	76–22	3/8 in
SM-12.5 A	0 to 3	64–22	1/2 in
SM-12.5 D	3 to 10	70–22	1/2 in
SM-12.5 E	Above 10	76–22	1/2 in
IM-19.0 A	Less than 10	64–22	3/4 in
IM-19.0 D	10 and above	70–22	3/4 in
BM-25.0 A	All ranges	64–22	1 in
BM-25.0 D	Above 10	70–22	1 in

¹Nominal maximum size is defined as one sieve size larger than the first sieve to retain more than 10% aggregate.

Asphalt concrete shall conform to the requirements for the type designated.

211.02—Materials

- (a) **Asphalt materials** shall conform to the requirements of Section 210 except asphalt cement materials shall be performance graded (PG) in accordance with the requirements of AASHTO M320. In addition, asphalt mixtures with the E designation shall meet the asphalt cement requirements in Section 211.04(e)1.
- (b) **Coarse aggregate** shall be Grade A or B, conforming to the requirements, except for grading, of Section 203 for quality. In addition, the coarse aggregate sizes retained on and above the No. 4 sieve shall comply with the coarse aggregate requirements in Table II–12A. Flat and elongated (F&E) particles shall be tested in accordance with the requirements of ASTM

D 4791, and coarse aggregate angularity (CAA) shall be tested on crushed gravel only in accordance with the requirements of ASTM D 5821.

- (c) **Fine aggregate** shall conform to the requirements except for grading of Section 202 for quality and the fine aggregate requirements in Table II-12A. Fine aggregate angularity (FAA) shall be tested in accordance with the requirements of AASHTO T 304 (Method A) and sand equivalent (SE) shall be tested in accordance with the requirements of AASHTO T 176.
- (d) After a gradation is performed:
 1. If 10 percent or more of the material is retained on the No. 4 sieve, that portion will be tested in accordance with the requirements for coarse aggregate.
 2. If 10 percent or more of the material passes the No. 4 sieve, that portion will be tested for SE.
 3. If 10 percent or more of the material passes the No. 8 sieve, that portion will be tested for FAA.
- (e) Fine or coarse aggregates that tend to polish under traffic will not be permitted in any final surface exposed to traffic except in areas where the two-way average daily traffic is less than 750 vehicles per day and as permitted elsewhere in these Specifications.
- (f) **Mineral filler** shall conform to the requirements of Section 201.
- (g) **Aggregate for asphalt concrete** shall be provided in sufficient sizes to produce a uniform mixture. The Contractor shall indicate on the proposed job-mix formula the separate approximate sizes of aggregate to be used.

Where segregation or nonuniformity is evident in the finished pavement, the Engineer reserves the right to require the Contractor to discontinue the use of crusher run or aggregate blends and to furnish separate sizes of open-graded aggregate material.

- (h) An **antistripping additive** shall be used in all asphalt mixes. It may be hydrated lime or an approved chemical additive from the Department's approved list found in the Materials Division's Manual of Instructions, or a combination of both.

The mixture shall produce a tensile strength ratio (TSR) not less than 0.80 for the design and production tests. The TSR shall be determined in accordance with AASHTO T283, including a freeze-thaw cycle (4-inch specimens compacted with a Marshall hammer or 3.5 by 6-inch specimens when compacted with a gyratory compactor), except that the 16-hour curing time requirement and the 72- to 96-hour storage period will be waived. Design tests shall use the same materials that are to be used in the production mix and shall be conducted in a laboratory approved by the Department.

TABLE II-12A
Aggregate Properties

Mix Type	Coarse Aggregate Properties			Fine Aggregate Properties	
	CAA		ASTM D4791 F & E “(5:1) % by weight	SE	FAA
	1 fractured face	2 fractured faces			
SM-9.0 A	85% min.	80% min.	10% max. ¹	40% min.	40% min.
SM-9.0 D	85% min.	80% min.	10% max. ¹	45% min.	45% min.
SM-9.0 E	95% min.	90% min.	10% max. ¹	45% min.	45% min.
SM-9.5 A	85% min.	80% min.	10% max. ¹	45% min.	45% min.
SM-9.5 D	85% min.	80% min.	10% max. ¹	45% min.	45% min.
SM-9.5 E	95% min.	90% min.	10% max. ¹	45% min.	45% min.
SM-12.5 A	85% min.	80% min.	10% max. ¹	45% min.	45% min.
SM-12.5 D	85% min.	80% min.	10% max. ¹	45% min.	45% min.
SM-12.5 E	95% min.	90% min.	10% max. ¹	45% min.	45% min.
IM-19.0 A	85% min.	80% min.	10% max. ¹	45% min.	45% min.
IM-19.0 D	95% min.	90% min.	10% max. ¹	45% min.	45% min.
BM-25.0 A	80% min.	75% min.	10% max. ¹	45% min.	45% min.
BM-25.0 D	80% min.	75% min.	10% max. ¹	45% min.	45% min.

¹ 10 percent measured at 5:1 on maximum to minimum dimensions

When a chemical additive is used, it shall be added to the asphalt cement prior to introduction into the mix. Any chemical additive or particular concentration of chemical additive found to be harmful to the asphalt material or that changes the viscosity of the original asphalt cement more than 400 poises or the penetration more than -4 or +10 shall be changed to obtain compliance with these values.

- (i) **Hydrated lime** shall conform to the requirements of ASTM C977. Hydrated lime shall be added at a rate of not less than 1 percent by weight of the total dry aggregate.

A separate bin or tank and feeder system shall be provided to store and accurately proportion the lime into the aggregate in either dry or slurry form. The lime and aggregate shall be mixed by pugmill or other approved means to achieve a uniform lime coating of the aggregate prior to entering the drier. In the event lime is added in dry form, the aggregate shall contain at least 3 percent free moisture. The stockpiling of lime treated aggregate will not be permitted.

The feeder system shall be controlled by a proportioning device, which shall be accurate to within ± 10 percent of the specified amount. The proportioning device shall have a convenient and accurate means of calibration. A flow indicator or sensor shall be provided with the proportioning device and interlocked with the plant controls, aggregate feed or weigh system, such that production of the mixture will be maintained and, if there is a stoppage of the lime feed, interrupted.

The method of introducing and mixing the lime and aggregate shall be subject to approval by the Engineer prior to beginning production.

- (j) **Reclaimed Asphalt Pavement (RAP)** material may be used as a component material of asphalt mixtures in conformance with the following:

1. Asphalt surface, intermediate, and base mixtures containing RAP shall use the PG grade of asphalt cement as indicated in Table II-14A.
2. The final asphalt mixture shall conform to the requirements for the type specified.
3. During the production process, RAP material shall not be allowed to contact open flame.
4. RAP material shall be handled, hauled, and stored in a manner that will minimize contamination. Further, the material shall be stockpiled and used in such manner that variable asphalt contents and asphalt penetration values will not adversely affect the consistency of the mixture.
5. RAP shall be processed in such a manner as to ensure that the maximum top size introduced into the mix shall be 2 inches. The Engineer may require smaller sized particles to be introduced into the mix if the reclaimed particles are not broken down or uniformly distributed throughout the mixture during heating and mixing.

211.03—Job-Mix Formula

The Contractor shall submit for the Engineer's approval a job-mix formula for each mixture to be supplied. The job-mix formula shall be within the design range specified. The job-mix formula shall establish a single percentage of aggregate passing each required sieve, a single percentage of asphalt material to be added to the aggregate, a temperature at which the mixture is to be produced, and a temperature at which the mixture is to be compacted for SUPERPAVE testing in accordance with the requirements of AASHTO R35. Each approved job-mix formula shall remain in effect, provided the results of tests performed on material currently being produced consistently comply with the requirements of the job-mix formula for grading, asphalt content, temperature, and SUPERPAVE compaction results and the requirements of Section 315.

- (a) SUPERPAVE mixes shall be designed and controlled in accordance with the requirements of AASHTO R35 and as specified herein. The Contractor shall have available all of the equipment outlined in AASHTO T312 (section 4–6) and a Department-certified Asphalt Mix Design Technician. The SUPERPAVE mixture shall be compacted in a gyratory compactor with an internal angle of 1.16 ± 0.02 degrees. The internal angle shall be measured and calibrated using a cold (non-mix) device. The SUPERPAVE Gyratory Compactor (SGC) shall be one from the Department's approved list found in the Materials Division's Manual of Instructions. The SUPERPAVE mixes shall conform to the requirements of Table II–13 and Table II–14. Section 7.1.2 of AASHTO R30 shall be modified such that the compaction temperature is as specified in (d) 6 herein.

The mixture shall be designed and compacted at the N design gyrations specified in Table II–14. The N Max. requirement shall be verified as part of the design process by compacting a minimum of two specimens at the design asphalt content.

- (b) In conjunction with the submittal of a job-mix formula, the Contractor shall submit complete SUPERPAVE design test data, ignition furnace calibration data in accordance with VTM-102 prepared by an approved testing laboratory, and viscosity data or supplier temperature recommendations for the asphalt cement if different from (d) 6 herein.
- (c) Three trial blends for gradation shall be run at one asphalt content. An aggregate blend that was previously developed and approved as a job-mix formula at a higher gyration level may be used for a subsequent year's mix designs that require a lower gyration level in lieu of developing three new trial blends.
- (d) The SUPERPAVE design test data shall include, but not be limited to, the following information:
 1. Grading data for each aggregate component of three trial blends shall be submitted to the Department. The data for the mixture will show percent passing for the following sieves: 2 inch, 1 1/2 inch, 1 inch, 3/4 inch, 1/2 inch, 3/8 inch, No. 4, No. 8, No. 16, No. 30, No. 50, No. 100, and No. 200. The grading shall be reported to the nearest 1.0 percent except the No. 200 sieve shall be reported to the nearest 0.1 percent.
 2. The test data shall include, but not be limited to, the percentage of each aggregate component as compared to the total aggregate in the asphalt mixture. The specific gravity and aggregate properties for coarse and fine aggregates defined in Section 211.02 (b) and (c), including flat and elongated properties, for each aggregate component or for the total aggregates used in the mixture shall be reported. Aggregate properties, except

TABLE II-13
Asphalt Concrete Mixtures: Design Range¹

Mix Type	Percentage by Weight Passing Square Mesh Sieves										
	2 in	1 1/2 in	1 in	3/4 in	1/2 in	3/8 in	No. 4	No. 8	No. 30	No. 50	No. 200
SM-9.0 A,D,E					100 ²	90-100	90 max.	47-67			2-10
SM-9.5 A,D,E					100 ²	90-100	80 max.	38-67			2-10
SM-12.5 A,D,E				100	95-100	90 max.	-	34-50			2-10
IM-19.0 A,D			100	90-100	90 max.	-	-	28-49			2-8
BM-25.0 A,D	100		90-100	90 max.	-	-	-	19-38			1-7
C (Curb Mix)					100	92-100	70-75	50-60	28-36	15-20	7-9

¹SM = Surface Mixture; IM = Intermediate Mixture; BM = Base Mixture; C = Curb Mixture.

²A production tolerance of 1% will be applied to this sieve regardless of the number of tests in the lot.

TABLE II-14
Mix Design Criteria

Mix Type	VTM (%) Production (Note 1)	VFA (%) Design	VFA (%) Production (Note 2)	Min. VMA (%)	Fines/Asphalt Ratio (Note 3)	No. of Gyration			Density (%) at N Initial
						N	Design	Initial	
SM-9.0 A ^{Notes 1,2,3}	2.0-5.0	75-80	70-85	16	0.6-1.3	65	7	100	≤ 90.5
SM-9.0 D ^{Notes 1,2,3}	2.0-5.0	75-80	70-85	16	0.6-1.3	65	7	100	≤ 89.0
SM-9.0 E ^{Notes 1,2,3}	2.0-5.0	75-80	70-85	16	0.6-1.3	65	7	100	≤ 89.0
SM-9.5 A ^{Notes 1,2,3}	2.0-5.0	73-79	68-84	15	0.6-1.2	65	7	100	≤ 90.5
SM-9.5 D ^{Notes 1,2,3}	2.0-5.0	73-79	68-84	15	0.6-1.2	65	7	100	≤ 89.0
SM-9.5 E ^{Notes 1,2,3}	2.0-5.0	73-79	68-84	15	0.6-1.2	65	7	100	≤ 89.0
SM-12.5 A ^{Notes 1,2,3}	2.0-5.0	70-78	65-83	14	0.6-1.2	65	7	100	≤ 90.5
SM-12.5 D ^{Notes 1,2,3}	2.0-5.0	70-78	65-83	14	0.6-1.2	65	7	100	≤ 89.0
SM-12.5 E ^{Notes 1,2,3}	2.0-5.0	70-78	65-83	14	0.6-1.2	65	7	100	≤ 89.0
IM-19.0 A ^{Notes 1,2,3}	2.0-5.0	69-76	64-81	13	0.6-1.2	65	7	100	≤ 90.5
IM-19.0 D ^{Notes 1,2,3}	2.0-5.0	69-76	64-81	13	0.6-1.2	65	7	100	≤ 89.0
BM-25.0 A ^{Notes 2,3,4}	2.0-5.0	67-75	62-83	12	0.6-1.3	65	7	100	≤ 89.0
BM-25.0 D ^{Notes 2,3,4}	2.0-5.0	67-75	62-83	12	0.6-1.3	65	7	100	≤ 89.0

¹SM = Surface Mixture; IM = Intermediate Mixture; BM = Base Mixture.

Note 1: Asphalt content should be selected at 4.0% air voids.

Note 2: During production of an approved job mix, the VFA shall be controlled within these limits.

Note 3: Fines-asphalt ratio is based on effective asphalt content.

Note 4: Base mix shall be designed at 3.5% air voids. BM-25.0 A shall have a minimum asphalt content of 4.4% unless otherwise approved by the Engineer. BM-25.0 D shall have a minimum asphalt content of 4.6% unless otherwise approved by the Engineer.

sand equivalent, shall be reported for RAP portions of a mixture. The aggregate specific gravity of RAP shall be the effective aggregate specific gravity calculated from the results of tests conducted in accordance with AASHTO T 209 and VTM-102.

3. The aggregate grading in the asphalt mixture shall be determined by igniting or extracting the asphalt from a laboratory-prepared sample. The laboratory sample shall be batched on the basis of component percentages as indicated in (d) 2. herein and at the proposed job-mix asphalt content. The aggregate shall be obtained in accordance with the requirements of VTM-102 or (VTM-36 when approved). Sieves specified in (d) 1. herein shall be reported, beginning with the top size for the mix.
4. The following volumetric properties of the compacted mixture, calculated on the basis of the mixture's maximum specific gravity determined in accordance with AASHTO T-209 shall be reported to the Engineer. The mixture shall be aged in accordance with AASHTO R30 and the bulk specific gravity of the specimens determined in accordance with AASHTO T-166, Method A, for each asphalt content tested. Properties shall be determined and reported in accordance with the requirements of AASHTO R35..
 - a. Voids in total mix (VTM)
 - b. Voids in mineral aggregate (VMA)
 - c. Voids filled with Asphalt (VFA)
 - d. Fines/Asphalt ratio (F/A)
5. The value of the maximum specific gravity of the asphalt mixture used in (c) 4. herein shall be reported to three decimal places.
6. The mixing and compaction temperature for testing shall be as follows:
 - a. For mix designation A , the mix temperature shall be 300 degrees F to 310 degrees F and the compaction temperature shall be 285 degrees F to 290 degrees F.
 - b. For mix designation D, the mix temperature shall be 310 degrees F to 320 degrees F and the compaction temperature shall be 295 degrees F to 300 degrees F.
 - c. In cases involving PG 76–22 or modified binders, the temperatures shall be based on documented supplier's recommendations.
7. The field correction factor as determined by subtracting the bulk specific gravity of the aggregate from the effective specific gravity of the aggregate at the design asphalt content.
8. Permeability test data shall be submitted in accordance with VTM-120 using either single point verification or the regression method for each surface mix having a different gradation. If the average of the permeability results from the single point verification method exceeds 150×10^{-5} cm/sec, or if the regression method predicts a permeability

exceeding 150×10^{-5} cm/sec at 7.5% voids, the Contractor shall redesign the mixture to produce a permeability number less than 150×10^{-5} cm/sec.

- (e) The SUPERPAVE design binder content test data shall be plotted on graphs as described in AASHTO R 35 and shall show that the proposed job-mix formula conforms to the requirements of the mix type.
- (f) A determination will be made that any asphalt concrete mixture being produced conforms to the job-mix formula approved by the Department. The Department and Contractor will test the mixture using samples removed from production. The following tests will be conducted to determine the properties listed:

Property	Test
Asphalt content	VTM-102, (VTM-36 when approved)
Gradation	AASHTO T-30
SUPERPAVE properties	AASHTO R35
Asphalt cement material	AASHTO T316 or T-201

At the discretion of the Engineer, the Department in accordance with VTM-110 will perform rut testing. If the results of the rut testing do not conform to the following requirements, the Engineer reserves the right to require adjustments to the job-mix formula:

Mix Designation	Maximum Rut Depth, mm
A	7.0
D	5.5
E, (M), (S)	3.5

In the event the Department determines that the mixture being produced does not conform to the approved job-mix formula and volumetric properties specified in Table II-14 based on the Department's or Contractor's test results, the Contractor shall immediately make corrections to bring the mixture into conformance with the approved job-mix formula or cease paving with that mixture.

Subsequent paving operations using either a revised or other job-mix formula that has not been verified as described herein shall be limited to a test run of 100 to 300 tons of mixture if such material is to be placed in Department project work. No further paving for the Department using that specific mixture shall occur until the acceptability of the mixture being produced has been verified using the 100 to 300 ton constraint.

Asphalt concrete mixtures used in surface, intermediate, and base courses shall conform to the following requirements when tested in accordance with the requirements of AASHTO R35:

TABLE II-14A
Recommended Performance Grade of Asphalt

Mix Type	Percentage RAP in Mix	
	0.0–20.0	Over 20.0
SM-9.0A, SM-9.5A, SM-12.5A	PG 64–22	PG 58–28
SM-9.0D, SM-9.5D, SM-12.5D	PG 70–22	PG 64–28
SM-9.0E, SM-9.5E, SM-12.5E	PG 76–22	PG 70–28
IM-19.0A	PG 64–22	PG 58–28
IM-19.0D	PG 70–22	PG 64–28
BM-25.0A	PG 64–22	PG 64–22 ¹
BM-25.0D	PG 70–22	PG 70–22 ¹

¹BM-25.0A mixes using more than 25% RAP shall use PG 58–22, and BM-25.0D mixes using more than 25% RAP shall use PG 64–22.

Based on rut testing performed by the Department and/or field performance of the job mix, the Engineer reserves the right to require adjustments to the job-mix formula.

211.04—Asphalt Concrete Mixtures

Asphalt concrete mixtures shall conform to the requirements of Table II-14 and the following:

- (a) **Types SM-9.0A, SM-9.0D, SM-9.0E, SM-9.5A, SM-9.5D, SM-9.5E, SM-12.5A, SM-12.5D, and SM-12.5E asphalt concrete** shall consist of crushed stone, crushed slag, or crushed gravel and fine aggregate, slag or stone screenings, or a combination thereof combined with asphalt cement.

NOTE: For all surface mixes, except where otherwise noted, no more than 5 percent of the aggregate retained on the No. 4 sieve and no more than 20 percent of the total aggregate may be polish susceptible. At the discretion of the Engineer, SM-9.5AL or SM-12.5AL may be specified and polish susceptible aggregates may be used (without percentage limits).

- (b) **Types IM-19.0A and IM-19.0D asphalt concrete** shall consist of crushed stone, crushed slag, or crushed gravel and fine aggregate, slag or stone screenings, or a combination thereof combined with asphalt cement.

NOTE: At the discretion of the Engineer, an intermediate mix may be designated as either SM-19.0A or SM-19.0D. When designated as such, no more than 5 percent of the aggregate retained on the No. 4 sieve may be polish susceptible. All material passing the No. 4 sieve may be polish susceptible.

- (c) **Types BM-25.0A and BM-25.0D asphalt concrete** shall consist of crushed stone, crushed slag, or crushed gravel and fine aggregate, slag or stone screenings, or a combination thereof combined with asphalt cement.
- (d) **Type C (curb mix) asphalt concrete** shall consist of a blend of No. 78 or No. 8 crushed aggregate, No. 10 crushed aggregate, fine aggregate, mineral filler, and a stabilizing additive from the Department's approved list found in the Materials Division's Manual of In-

structions combined with 6.0 to 9.0 percent of PG 64–22. This mix does not require a volumetric mix design or volumetric testing under the SUPERPAVE system.

- (e) **Type SM-9.5, SM-12.5, IM-19.0, and BM-25.0 asphalt concrete** may be designated (M) for modified, (S) for stabilized, or (M) or (S) for Contractor’s option. Asphalt mixtures with the E designation may be modified but shall not be stabilized.
1. **Type (M) asphalt mixtures** shall consist of mixes incorporating a neat asphalt material with polymer modification complying with the requirements of PG 76–22 and have a rolling thin film oven test residue elastic recovery at 77 degrees F of a minimum 70 percent. Modified mixtures shall be designated with an (M) following the standard mix designation. Type (M) asphalt mixtures shall not be permitted to exceed 15 percent reclaimed asphalt pavement (RAP) material.
 2. **Type (S) asphalt mixtures** shall consist of mixes incorporating a stabilizing additive from the the Department’s approved list found in the Materials Division’s Manual of Instructions. These mixes shall be designated with an (S) following the standard mix designation. The minimum required additive shall be as specified on the Department’s approved list found in the Materials Division’s Manual of Instructions.

211.05—Testing

The Contractor shall provide the quality control and assurance necessary for the Department to determine conformance with the required grading, asphalt content, and temperature properties for asphalt concrete.

The Contractor shall have a Department-certified Asphalt Mix Design Technician for designing and adjusting mixes as necessary. The Asphalt Mix Design Technician or Asphalt Plant Technician may perform testing of asphalt mixes. The Asphalt Mix Design Technician shall be responsible for reviewing and approving the results of all testing. The Asphalt Mix Design Technician shall be available and have direct communication with the plant for making necessary adjustments in the asphalt concrete mixes at the mixing plant. The Asphalt Mix Design Technician and Asphalt Plant Technician shall each be capable of conducting any tests necessary to put the plant into operation; however, the Asphalt Mix Design Technician shall be responsible for producing a mixture that complies with the requirements of these Specifications. The Department will award certification.

The Contractor shall maintain all records and test results associated with the material production and shall maintain appropriate current quality control charts. Test results and control charts shall be available for review by the Engineer.

The Contractor shall execute a quality control plan of process inspections and tests, including the determination of SUPERPAVE properties. The results of the SUPERPAVE tests shall be used, along with the results of other quality control efforts, to control the quality of the mixture being produced.

The Contractor shall perform at least one field SUPERPAVE test per day per mix or per 1,000 tons per mix if more than 1,000 tons of a mix is produced per day. Aging as described in AASHTO R30 shall not be performed. In the event less than 300 tons of asphalt mixture is produced under a single job-mix formula in a day, field SUPERPAVE testing will not be required. This tonnage shall be added to subsequent production. When the accumulated tonnage exceeds 300 tons, minimum testing frequency shall apply. Field SUPERPAVE test results shall be plotted and displayed in control chart

form in the plant immediately following the completion of each individual test. The tests shall determine asphalt content, VTM, VMA, VFA, and F/A in percentages to the nearest 0.1 percent. The Department will conduct on-site inspections so the Contractor's Asphalt Mix Design Technician can demonstrate a knowledge of the SUPERPAVE mix design and production requirements on Department-supplied mixture.

Aggregate specific gravity and aggregate property tests shall be conducted by a Department-certified Aggregate Properties Technician or Asphalt Mix Design Technician on each aggregate component (including RAP) or total aggregate mixture once at design and once prior to beginning production in each calendar year. Sand equivalent shall not be determined on RAP. In addition, for each 50,000 tons of each aggregate size used at each plant, aggregate specific gravity and the results aggregate property tests shall be reported for each aggregate component or the total aggregate mixture. Otherwise, if the total blend (cold feed) is used to determine aggregate specific gravity and aggregate properties, these tests shall be run for each 50,000 tons of the total blend.

Field SUPERPAVE tests shall be performed to N_{design} gyrations as specified in Table II-14. At the Engineer's discretion, the N_{max} requirement may be verified

211.06—Tests

The Department may sample materials entering into the composition of the asphalt concrete, the mixture, or the completed pavement. The Contractor shall cooperate with the Engineer in obtaining these samples. When samples are obtained from the pavement, the resulting voids shall be filled and refinished by the Contractor without additional compensation.

When asphalt cement is extracted and recovered in accordance with AASHTO T170, the recovered asphalt cement shall have the following penetration:

Mix Type	Recovered Penetration	Ductility at 77°F
SM-9.0A, 9.5A, 12.5A	Min. 35	Min 40 cm
SM-9.0D, 9.5D, 12.5D	Min. 25	Min 40 cm
IM-19.0A	Min. 35	Min 40 cm
IM-19.0D	Min. 25	Min 40 cm
BM-25.0A	Min. 35	Min 40 cm
BM-25.0D	Min. 25	Min 40 cm

NOTE: Penetration and Ductility tests on the recovered asphalt cement shall not be performed on SM-9.5E, 12.5E, and all (M) and (S) mixes.

Abson recovery samples that fail penetration shall be PG graded in accordance with AASHTO M320. If the samples comply with the required grade specified in Section 211.01, they will be deemed acceptable.

When the Department performs PG grading on the asphalt in a Contractor's liquid asphalt storage tank, the Engineer will notify the asphalt concrete producer and binder supplier if tests indicate that the binder properties of the asphalt material differ from those of the approved job-mix. The asphalt concrete producer and binder supplier shall determine corrective action with the approval of the Engineer.

211.07—Plant Inspection

The preparation of asphalt concrete mixtures will be accepted under a quality assurance plan. The Contractor shall provide a laboratory as specified in Section 106.07.

In addition, the Contractor shall have all laboratory scales and gyratory compactors calibrated once a year by an independent source. The Contractor shall maintain the calibration records for 3 years.

211.08—Acceptance

Acceptance will be made under the Department's quality assurance program, which includes the testing of production samples by the Contractor and of monitor samples by the Department. Sampling and testing for the determination of grading, asphalt cement content, and temperature shall be performed by the Contractor, and the Department will perform independent monitor checks at a laboratory of its choosing. The Contractor shall provide copies of such test results to the Department on forms furnished by the Department. Where the Contractor's test results indicate that the mixture conforms to the gradation, asphalt cement content, and mix temperature requirements of the Specifications, the mixture will be acceptable for these properties; however, nothing herein shall be construed as waiving the requirements of Section 106.06, Section 200.02, Section 200.03, and Section 315 or relieving the Contractor of the obligation to furnish and install a finished functional product that conforms to the requirements of the Contract. In the event a statistical comparative analysis of the Contractor's test results and the Department's monitor tests indicate a statistically significant difference in the results and either of the results indicates that the material does not conform to the grading and asphalt cement content requirements of the Specifications, an investigation will be made to determine the reason for the difference. In the event it is determined from the investigation that the material does not conform to the requirements of the Contract, price adjustments will be made in accordance with the requirements of Section 211.09.

Acceptance for gradation and asphalt cement content will be based on a mean of the results of four tests performed on samples taken in a stratified random manner from each 2,000-ton lot (4,000-ton lots may be used when the normal daily production of the source from which the material is being obtained is in excess of 2,000 tons). Unless otherwise approved, samples shall be obtained from the approximate center of truckloads of material. Any statistically acceptable method of randomization may be used to determine the time and location of the stratified random sample to be taken; however, the Department shall be advised of the method to be used prior to the beginning of production.

A lot will be considered to be acceptable for gradation and asphalt content if the mean of the test results obtained is within the tolerance allowed for the job-mix formula as specified in Table II-15.

The temperature of the mixture at the plant shall be controlled to provide load-to-load uniformity during changing weather conditions and surface temperatures. The maximum temperature of mix designations A and D and base mixes shall not exceed 350 degrees F unless otherwise directed by the Engineer. The maximum temperature as recommended by the supplier shall not be exceeded for a mix designated E, (M), or (S).

In the event the job-mix formula is modified within a lot, the mean test results of the samples taken will be compared to the applicable process tolerance shown in Table II-15.

Asphalt content will be measured as extractable asphalt or weight after ignition.

TABLE II-15
Process Tolerance

No. Tests	Tolerance on Each Laboratory Sieve and Asphalt Content: Percent Plus and Minus											A.C.
	Top Size ¹	1 1/2 in	1 in	3/4 in	1/2 in	3/8 in	No. 4	No. 8	No. 30	No. 50	No. 200	
1	0.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	6.0	5.0	2.0	.60
2	0.0	5.7	5.7	5.7	5.7	5.7	5.7	5.7	4.3	3.6	1.4	0.43
3	0.0	4.4	4.4	4.4	4.4	4.4	4.4	4.4	3.3	2.8	1.1	0.33
4	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.0	2.5	1.0	0.30
8	0.0	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.1	1.8	0.7	0.21

¹Defined as the sieve that has 100% passing as defined in Table II-13.

Field SUPERPAVE tests will be performed by the Department in accordance with the requirements of AASHTO R35 during the production of the approved job mixes designed by the SUPERPAVE method. Aging, as described in AASHTO R30, shall not be performed. Should any field SUPERPAVE test fail with regard to the limits specified in Table II-14, the Department may require that production be stopped until necessary corrective action is taken by the Contractor. The Engineer will investigate and determine the acceptability of material placed and represented by failing field SUPERPAVE test results.

Should visual examination by the Engineer reveal that the material in any load or portion of the paved roadway is obviously contaminated or segregated, that load or portion of the paved roadway will be rejected without additional sampling or testing of the lot. In the event it is necessary to determine the gradation or asphalt content of the material in any load or portion of the paved roadway, samples will be taken and tested and the results will be compared to the requirements of the approved job-mix formula. The results obtained in the testing will apply only to the material in question.

211.09—Adjustment System

In the event a lot of material does not conform to the acceptance requirements of Section 211.08, adjustment points will be determined as follows:

Adjustment Points for Each 1% the Gradation Is Outside the Process Tolerance Permitted In Table II-15

Sieve Size	(Applied in 0.1% increments)
1 1/2 in	1
1 in	1
3/4 in	1
1/2 in	1
3/8 in	1
No. 4	1
No. 8	1
No. 30	2
No. 50	2
No. 200	3

One adjustment will be applied for each 0.1 percent that the material is out of the process tolerance for asphalt content.

In the event the total adjustment for a lot is greater than 25 points, the failing material shall be removed from the road. In the event the total adjustment is 25 points or less and the Contractor does not elect to remove and replace the material, the unit price for the material will be reduced 1 percent of the unit price bid for each adjustment point. The adjustment will be applied to the tonnage represented by the sample(s). In the event adjustment points are applied against two successive lots, plant adjustment shall be made prior to continuing production.

The Contractor shall control the variability of his product in order to furnish a uniform mix. When the quantity of any one type of material furnished a project exceeds 4,000 tons, the variability of the total quantity furnished will be determined on the basis of the standard deviation for each sieve size and the asphalt content. In the event the standard deviation is within the ranges specified in Table II-16, the

unit bid price for the material will be adjusted as indicated herein. Adjustments for standard deviation computations will not be made on more than two job mixes for the same type of material.

TABLE II-16
Standard Deviation

Sieve Size and A.C.	Standard Deviation 1 Adjustment Point for Each Sieve Size and A.C.	2 Adjustment Points for Each Sieve Size and A. C.	3 Adjustment Points for Each Sieve Size and A.C.
1/2 in.	3.8–4.7	4.8–5.7	5.8–6.7
3/8 in	3.8–4.7	4.8–5.7	5.8–6.7
No. 4	3.8–4.7	4.8–5.7	5.8–6.7
No. 8	3.0–3.9	4.0–4.9	5.0–5.9
No. 30	2.2–3.1	3.2–4.1	4.2–5.1
No. 50	1.5–2.4	2.5–3.4	3.5–4.4
No. 200	1.1–2.0	2.1–3.0	3.1–4.0
A.C.	0.27–0.36	0.37–0.46	0.47–0.56

A separate standard deviation will be determined by the Department for each calendar year's production of each mix type produced by a plant.

The unit bid price will be reduced by 0.5 percent for each adjustment point applied for standard deviation.

The Engineer will determine the disposition of material having standard deviations larger than those specified in Table II-16.

211.10—Referee System

- (a) **In the event the test results obtained from one of the four samples taken to evaluate a particular lot appear to be questionable**, the Contractor may request in writing that the results of the questionable sample be disregarded, whereupon the Contractor shall have either an AASHTO-accredited lab or Department lab perform tests on five additional samples taken from randomly selected locations in the roadway where the lot was placed. In the event the Engineer determines that one of the four tests results appears to be questionable, the Department will perform tests on five additional samples taken from randomly selected locations in the roadway where the lot was placed. The test results of the three original, i.e., unquestioned, samples will be averaged with the test results of the five road samples, and the mean of the test values obtained for the eight samples will be compared to the requirements for the mean of eight tests as specified in Table II-15.
- (b) **In the event the Contractor questions the mean of the four original test results obtained for a particular lot**, the Contractor may request in writing approval to have either an AASHTO-accredited lab or Department lab perform additional testing of that lot. In the event the Engineer determines that the mean of the four original test results are questionable, the Department will perform additional testing of that lot. The test results of the original four samples will be averaged with the test results of the four additional samples taken

from randomly selected locations in the roadway where the lot was placed, and the mean of test values obtained for the eight samples will be compared to the requirements for the mean result of eight tests as specified in Table II–15.

If the Contractor requests additional tests, as described in (a) or (b) herein, the Contractor shall sample the material and have either an AASHTO-accredited lab or Department lab test the material in accordance with Department-approved procedures. The Engineer reserves the right to observe the sampling and testing.

In the event the mean of the test values obtained for the eight samples conforms to the requirements for the mean results of eight tests, the material will be considered acceptable. In the event the mean of the test values obtained for the eight samples does not conform to the requirements for the mean result of eight tests, the lot will be adjusted in accordance with the adjustment rate specified in Section 211.09.

Samples of the size shown herein shall be saw cut by the Contractor for testing without the use of liquids:

Application Rate	Minimum Sample Size
125 lb/yd ²	8 by 8 in
150 lb/yd ²	7 by 7 in
200 lb/yd ²	6 by 6 in
300 lb/yd ²	5 by 5 in

211.11—Handling and Storing Aggregates

Aggregates shall be handled, hauled, and stored in a manner that will minimize segregation and avoid contamination. Aggregates shall be stockpiled in the vicinity of the plant and on ground that is denuded of vegetation, hard, well drained, or otherwise prepared to protect the aggregate from contamination. Placing aggregate directly from the crusher bins into the cold feed may be permitted provided the material is consistent in gradation. When different size aggregates are stockpiled, the stockpiles shall be separated to prevent commingling of the aggregates.

211.12—Asphalt Concrete Mixing Plant

Plants used for the preparation of asphalt concrete mixtures shall conform to the following requirements:

- (a) **Certification for Plant Operation and Sampling:** A Certified Asphalt Plant Technician shall sample material at the plant.
- (b) **Plant Scales:** Scales shall be approved in accordance with the requirements of Section 109.01.
- (c) **Drier:** The plant shall include a drier(s) that continuously agitates the aggregate during the heating and drying process. The aggregate shall be dried to a point at which the moisture content of the completed mixture does not exceed 1 percent as determined from samples taken at the point of discharge from the mixing operation.

- (d) **Feeder for Drier:** The plant shall be equipped with accurate mechanical means for uniformly feeding the aggregate into the drier so that a uniform production and uniform temperature will be obtained. Where different size aggregates are required to comply with grading specifications, they shall be proportioned by feeding into the cold elevator through a multiple compartment feeder bin, one bin for each size used, equipped with positive action gates that can be securely locked to maintain desired proportioning.
- (e) **Bins:** When bins are used, adequate and convenient facilities shall be provided to make possible the sampling of representative aggregate material for each bin. Each compartment shall be provided with an overflow pipe of such size and at such location to prevent contamination of the aggregate in adjacent compartments and shall be provided with individual outlet gates that, when closed, will allow no leakage.
- (f) **Thermometric Equipment:** The plant shall be equipped with a thermometric instrument so placed at the discharge chute of the drier as to register automatically or indicate the temperature of the heated aggregate or the completed mix if the drier drum mixing plant is used.

A thermometric device shall be fixed in the asphalt feed line at a suitable location near the charging valve at the mixer unit.

Thermometric devices shall be maintained in good working condition and shall be subject to checking against the laboratory thermometer. Any instruments that do not operate or register properly shall be removed and repaired or replaced.

- (g) **Pollution Control:** Pollution control shall conform to the requirements of Section 107.16.
- (h) **Equipment for Preparation of Asphalt Material:** Tanks for the storage of asphalt material shall be equipped with a heating system capable of heating and holding the material at the required temperatures. A separate storage tank or a storage tank having separate compartments shall be available for each grade of asphalt cement being used. The heating system shall be designed to heat the contents of the tank by means of steam, electricity, or other approved means so that no flame is in contact with the heating surface of the tank. The circulating system for the asphalt material shall be designed to assure proper and continuous circulation during the operating period and to minimize oxidation. Pipelines shall be steam jacketed or insulated to prevent undue loss of heat. Storage facilities for asphalt material shall be sufficient for at least one day's operation or an equivalent means of supply shall be provided that will ensure continuous operation. Provisions shall be made for measuring and sampling storage tanks. When asphalt material is proportioned by volume, the temperature of the asphalt material in storage shall be uniformly maintained at ± 20 degrees F during operation of the plant by means of an automatic temperature control device. A sampling valve shall be provided for sampling of each asphalt storage tank used in production of the mix. If there are multiple storage tanks, a dedicated valve for each tank shall be provided.
- (i) **Asphalt Control:** Asphalt material shall be accurately proportioned by volume or weight. When volumetric methods are used, measurements shall be made by means of meters or pumps, calibrated for accuracy. The section of the asphalt line between the charging valve and the spray bar shall be provided with an outlet valve for checking the meter.

When proportioned by weight, the asphalt material shall be weighed on approved scales. Dial scales shall have a capacity of not more than 15 percent of the capacity of the mixer. The value of the minimum graduation shall not be greater than 2 pounds.

Except when a drier-drum mixing plant is used, the asphalt material bucket and its valves and spray bar shall be steam jacketed or heated by other approved means. The bucket shall have a capacity of at least 115 percent of the weight of the asphalt material required in any mixture and shall be supported by fulcrums.

The asphalt shall be delivered to the mixer in multiple uniform streams for the full width of the mixer.

- (j) **Proportioning Aggregates:** Mineral filler and any bag house fines the Contractor uses shall be metered or introduced by means of an approved device for uniform proportioning by weight or by volume.

The weigh hopper shall be of sufficient size to hold the maximum required weight of aggregate for one batch without hand raking or running over. Sufficient clearance between the weigh hopper and supporting devices shall be provided to prevent accumulation of foreign materials.

The discharge gate of the weigh hopper shall be situated in such a manner that the aggregates will not segregate when dumped into the mixer. Gates on the bins and weigh hopper shall be constructed to prevent leakage when closed.

- (k) **Drum Mixer:** The aggregate shall be proportioned by a positive weight control at the cold aggregate feed by use of a belt scale that will automatically regulate the supply of material being fed and permit instant correction of variations in load. The cold feed flow shall be automatically coupled with the asphalt flow to maintain the required proportions.
- (l) **Batch Mixer:** The batch mixer shall be of a twin pugmill or other approved type, steam jacketed or heated by other approved means, and capable of producing uniform mixtures within the specified tolerances. It shall be equipped with a sufficient number of paddles or blades, operated at such speeds as to produce a properly and uniformly mixed batch. The number and arrangement of the mixer paddles shall be subject to the approval of the Engineer. Worn or defective blades shall not be used in mixing operations.

The mixer shall be provided with an approved time lock that will lock the discharge gate after the aggregates and asphalt have been placed in the mixer and will not release the gate until the specified time has elapsed.

Batch-type mixing plants used to produce asphalt concrete shall be equipped with approved automatic proportioning devices. Such devices shall include equipment for accurately proportioning batches of the various components of the mixture by weight or volume in the proper sequence and for controlling the sequence and timing of mixing operations. The automated system shall be designed to interrupt and stop the batching operation at any time batch quantities are not satisfied for each of the materials. A means shall be provided for observing the weight of each material during the batching operation.

The aggregate may be proportioned by cold feed controls in lieu of plant screens provided the cold aggregate feed conforms to the requirements specified in (j) herein.

Should the automatic proportioning devices become inoperative, the plant may be allowed to batch and mix asphalt materials for a period of not more than 48 hours from the time the breakdown occurs provided alternate proportioning facilities are approved by the Engineer.

Written permission of the Engineer will be required for operation without automatic proportioning facilities for periods longer than 48 hours.

- (m) **Continuous Mixing Plant:** A continuous mixing plant shall include a means for accurately proportioning each size of aggregate either by weighing or volumetric measurement. When gradation control is by volume, the unit shall include a feeder mounted under the compartment bins. Each bin shall have an accurately controlled individual gate to form an orifice for volumetrically measuring the material drawn from each respective bin compartment. The orifice shall be rectangular, with one dimension adjustable by positive mechanical means, and shall be provided with a lock. Indicators shall be provided to show the individual gate opening in inches. The plant shall be equipped with a satisfactory revolution counter.

The plant shall include a means for calibrating gate openings by weight. The materials fed out of the bins through individual orifices shall be bypassed to a suitable test box, with each component material confined in a separate section. The plant shall be equipped to conveniently handle test samples weighing up to 200 pounds per bin, and accurate platform scales shall be provided for this purpose.

Positive interlocking control shall be provided between the flow of aggregate from the bins and the flow of asphalt material from the meter or other proportioning device. This shall be accomplished by approved interlocking devices or other approved positive means.

Accurate control of the asphalt material shall be obtained by weighing, metering, or volumetric measurement.

The aggregate may be proportioned by cold feed controls in lieu of plant screens provided the cold aggregate feed conforms to the requirements specified in (j) herein.

The plant shall include a continuous mixer of an approved type that is steam jacketed or heated by other approved means. The paddles shall be of any adjustable type for angular position on the shafts and reversible to retard the flow of the mixture.

Interlock cutoff circuits shall be included to interrupt and to stop the proportioning and mixing operations when the aggregate level in the plant or the asphalt material in storage falls below that necessary to produce the specified mixture.

- (n) **Trucks, Truck Scales, and Automatic Printer System:** These shall conform to the requirements of Section 109.01.

211.13—Preparation of Mixture

The asphalt and aggregate shall be introduced into the mixer at a temperature that will produce a mixture that conforms to the requirements of the job-mix formula.

After the required amounts of aggregate and asphalt material have been introduced into the mixer, the materials shall be mixed until a uniform coating of asphalt and a thorough distribution of the aggregate throughout the mixture are secured that comply with the requirements of the Ross count procedure in AASHTO T195. Wet mixing time, based on the procedures in AASHTO T195, shall be determined by the Contractor at the beginning of production and will be approved by the Engineer for each individual plant or mixer and for each type of aggregate used; however, in no case shall the wet mix-

ing time be less than 20 seconds. The *wet mixing time* is the interval of time between the start of introduction of the asphalt material into the mixer and the opening of the discharge gate. A wet mixing time that will result in fully coating a minimum of 95 percent of the coarse particles, based on the average of the three samples is acceptable, provided that none of the three samples result has a coating less than 92 percent of the coarse particles shall be the minimum wet mixing time requirement. A dry mixing time of up to 15 seconds may be required by the Engineer to accomplish the degree of aggregate distribution necessary to obtain complete and uniform coating of the aggregate with asphalt.

211.14—Storage System

In the event the Contractor elects to use a storage system, the system shall be capable of conveying the mix from the plant to the storage bins and storing the mix without a loss in temperature, segregation, or oxidation of the mix. Storage time shall be limited by the ability of the bins to maintain the mix within the quality requirements specified herein with a maximum time limit not to exceed 10 days. Material may be stored in bins for no more than 24 hours without an approved heating system.

The conveyor system may be a continuous or skip bucket type. Continuous type conveyors shall be enclosed so that the mix temperature is maintained.

The storage bins shall be designed in a manner to prevent segregation of the mix during discharge from the conveyor into the bins and shall be equipped with discharge gates that will not cause segregation of the mix while the mix is loaded into the trucks.

Approval for the use of storage bins may be withdrawn by the Engineer in the event the amount of heat loss, segregation, or oxidation of the mix is excessive.

211.15—Initial Production

At the start of production of a mix not previously used on a state roadway, the Contractor shall place 100 to 300 tons or up to one day's production as directed by the Engineer at an approved site, which may be the project site, so the Engineer can examine the process control of the mixing plant, the Contractor's placement procedures, surface appearance of the mix, compaction patterns of the Contractor's roller(s), and correlation of the nuclear density device. The material shall be placed at the specified application rate and will be paid for at the contract unit price for the specified mix type. The Engineer will determine the disposition of material that was not successfully produced and/or placed due to negligence in planning, production, or placement by the Contractor.

SECTION 212—JOINT MATERIALS

212.01—Description

These specifications cover resilient products made from various materials that are designed to accommodate the movement of rigid structures, such as component parts of hydraulic cement concrete, and seal the joint from intrusion of water or incompressibles.

212.02—Detail Requirements

- (a) **Hot-poured joint sealer** shall be heated in accordance with the manufacturer's recommendations.
1. **Asphalt sealer** shall conform to the requirements of ASTM D6690, Type II.
 2. **Elastomeric joint sealer** shall conform to the requirements of ASTM D3406 and shall be used only for longitudinal joints.
- (b) **Silicone sealants** shall be furnished in a one- or two-part formulation. The sealant shall be compatible with the surface to which it is applied. Acid-cure sealants are not acceptable for use on hydraulic cement concrete. Bond breakers shall be chemically inert and resistant to petroleum products, solvents, and primers.

Silicone sealants will be identified in the following manner:

1. **Class A:** A low-modulus non-sag silicone for use in sealing horizontal and vertical joints in hydraulic concrete pavements and structures. Tooling is required.
2. **Class B:** A very-low-modulus self-leveling silicone used to seal horizontal joints in hydraulic cement concrete pavements and structures. Tooling is not normally required.
3. **Class C:** An ultra-low-modulus self-leveling silicone used to seal horizontal joints in hydraulic cement concrete pavements and structures. It can also be used to seal the joints between hydraulic cement concrete pavement and asphaltic concrete shoulders. Tooling is not normally required.
4. **Class D:** An ultra-low-modulus self-leveling rapid-curing two-part silicone used to seal expansion joints on bridge decks. It can also be used to seal joints subject to dynamic movements where rapid curing is necessary. Tooling is not normally required.

Silicone sealants shall conform to the following physical requirements:

Properties	Test Method	Sealant Class			
		A	B	C	D
Tensile stress at 150% strain (max. psi) (Note 1)	ASTM C1135	45	40	15	25
Durometer hardness, Shore (0° and 77°± 3°F) (Note 1)	ASTM D2240	“A” 10–25	“00” 40–80	“00” 20–80	“00” 40–80
Bond to concrete mortar (min. psi) (Notes 1 and 3)	VTM-90	50	40	35	35
Tack-free time (skin-over) (max. min) (Note 2)	VTM-90 (Note 4)	180	180	180	30
Extrusion rate (min. g/min)	VTM-90	75	90	100	200
Non-volatile (min. %) specific gravity	VTM-90 ASTM D792 (Method A)	90 1.1–1.5	90 1.1–1.5	90 1.1–1.5	90 1.2–1.5
Shelf life (from date of shipment)		6 mo	6 mo	6 mo	6 mo
Movement capability and adhesion (Note 1)	VTM-90	No adhesive or cohesive failure after 10 cycles at 0°F			
Ozone and UV resistance (Note 1)	ASTM C-793–75	No chalking, cracking, or bond loss after 5,000 hr			

Note 1: The cure time for these specimens shall be 21 days for Class A and 28 days for Classes B and C. Specimens shall be cured at 77° ± 3°F and 50 ± 5% relative humidity.

Note 2: At conditions of 77° ± 3°F and 50 ± 5% relative humidity.

Note 3: Class C silicone shall also attain its bond strength requirement to asphalt concrete.

Note 4: In cases of dispute, ASTM D2377 shall be used as a referee test. The exposure period in Section 7, Procedure, shall be the tack-free time requirement of this specification.

Bond breakers: The bond breaker shall not stain or adhere to the sealant. Bond breakers shall be either a backer rod or tape identified and used in accordance with the following:

1. Backer Rods:

Type L: A closed-cell expanded polyethylene foam backer rod. This backer rod may be used with Class A silicone only and is suitable for roadway and structure joints.

Type M: A closed-cell polyolefin foam backer rod that has a closed-cell skin over an open-cell core. This backer rod may be used with all three types of sealants and is suitable for use in roadway and structure joints.

Backer rods shall conform to the following requirements:

Property	Test Procedures	Physical Requirements
Density	ASTM D1622	Min. 2.0 lb/ft ³
Tensile strength	ASTM D1623	Min. 25 psi
Water absorption	ASTM C509	Max. 0.5% by volume

2. **Bond Breaking Tapes: Type N:** Bond breaking tape shall be made from extruded polyethylene and shall have a pressure-sensitive adhesive on one side. Bond breaking tapes may be used with all three types of sealants but is suitable for structure joints only.

Bond breaking tapes shall be not less than 0.005-inch thick.

The manufacturer of the joint sealant shall furnish certified test results on each lot of sealant furnished to a project. The certified test results shall include all test results except the bond to concrete mortar and shore durometer hardness at 0 degrees F.

Only those silicone sealants that appear on the latest approved products list published by the Department's Materials Division will be permitted for use.

Silicone sealants submitted for initial approval and conforming to the material requirements of this specification will not be approved until field evaluations are made. The material shall be installed in roadway or bridge joints and shall go through two winters without failure before being approved. After approval, the material will be placed on the Department's approved products list.

Even though a sealant or bond breaker has been evaluated and approved, failure to perform adequately in actual use will be just cause for rejection.

- (c) **Preformed expansion joint filler** shall conform to the requirements of AASHTO M213.
- (d) **Expanded rubber joint filler** shall conform to the requirements of ASTM D1056.
- (e) **Preformed neoprene (polychloroprene) seals** shall conform to the requirements of ASTM D1056, Grade 2B3. (Modification requires that material be manufactured from neoprene.)
- (f) **PVC and PE joint fillers** shall conform to the requirements of ASTM D1667. Grades VE-43 BL to VE-45 BL shall be furnished. Adhesives for use with this material shall be as recommended by the manufacturer.
- (g) **Sponge rubber joint filler** shall conform to the requirements of AASHTO M153, Type I. When used in conjunction with bridge bearings, the load required to compress the test specimen to 50 percent of its thickness before the test shall be not more than 100 pounds per square inch.
- (h) **Gaskets for pipe** shall conform to the following: Rubber gaskets for ductile iron pipe and fittings shall conform to the requirements of AWWA C111; rubber gaskets for all other pipe shall conform to the requirements of ASTM C443 and the ozone cracking resistance described in Section 237.02.

Preformed plastic gaskets shall conform to the requirements of AASHTO M198.

Preformed plastic gaskets shall conform to the requirements of AASHTO M198, Type B.

- (i) **Preformed elastomeric joint sealer** shall be a vulcanized elastomeric compound in which noncrystallizing neoprene is used as the sole polymer. Sealer shall be resilient and resistant to heat, oil, and ozone.

The seal shall conform to the following as evidenced by samples cut from the finished product:

Property	Test Procedures	Physical Requirements
Tensile strength	ASTM D412	2,000 psi min.
Elongation at break	ASTM D412	250% min.
Hardness (durometer, Shore A)	ASTM D2240	55 ± 5
Tensile strength (change) After Oven aging (70 hr at 212°F) IAW ASTM D573	ASTM D412	-40% max.
Elongation (change) After Oven aging (70 hr at 212°F) IAW ASTM D573	ASTM D412	-40% max.
Hardness (points change) After Oven aging (70 hr at 212°F) IAW ASTM D573	ASTM D2240	+10% max.
Ozone resistance (20% strain, 100 pphm in air, 300 hr at 104°F) (wipe with solvent to remove surface contamination)	ASTM D1149	No cracks
High-temperature recovery (72 hr at 212°F under 50% deflection)	VTM-3	85% (no web adhesion or cracks)
Low-temperature recovery (72 hr at 14°F under 50% deflection)	VTM-3	87%
Low-temperature recovery (22 hr at -20°F under 50% deflection)	VTM-3	82%

When tested at a temperature of 70 ± 5 degrees F, the seal shall also conform to the following:

Use	Deflection Based on Nominal Width (%)	Pressure (psi)
Pavement	20	Min. 3
	50	Max. 15
Structure	20	Min. 4
	50	Max. 40

After aging at 212 degrees F for 70 hours at 50 percent deflection, the seal shall conform to the following:

Use	Deflection Based on Nominal Width (%)	Pressure (psi)
Pavement	20	Min. 1.0
	50	Max. 15
Structure	20	Min. 1.5
	50	Max. 40

Lubricant adhesive shall be a one-component polyurethane compound with an aromatic hydrocarbon solvent and shall conform to the requirements for physical properties of ASTM D4070.

Lubricant for pavement seals shall conform to the requirements of ASTM D2835.

- (j) **Elastomeric Expansion Dam and Tooth Expansion Joint:** The elastomeric sheet gland material shall be virgin ethylene propylene diene monomer (EPDM) or virgin polychloroprene. The elastomeric material shall have the following physical properties:

Property	Test Procedures	Physical Requirements
Tensile strength	ASTM D412	1,500 psi min.
Elongation at break	ASTM D412	175% min.
Low-temperature brittleness	ASTM D746	Not brittle at -40°F
Oil deterioration (no requirement for EPDM material), volume increase after 70-hr immersion in ASTM Oil No. 3 at 212°F	ASTM D471	120% max.
Ozone resistance: exposure to 100 ppm ozone in air for 70 hr at 100°F under 20% strain	ASTM D1149	No cracks
Hardness, Durometer A	ASTM D2240	50-60

The elastomeric strip seal gland material shall be preformed, non-reinforced, polychloroprene and shall have the following properties.

Property	Test Procedures	Physical Requirements
Tensile strength	ASTM D412	2,000 psi min.
Elongation at break	ASTM D412	250% min.
Hardness, Durometer A, points	ASTM D2240 (Modified) ^{1,2}	60 ± 5
Tensile strength, loss after Oven aging, 70 hr at 212°F IAW ASTM D573	ASTM D412	20% max.
Elongation, loss after Oven aging, 70 hr at 212°F IAW ASTM D573	ASTM D412	20% max.
Hardness, Durometer A, points After Oven aging (70 hr at 212°F) IAW ASTM D573	ASTM D2240 (Modified) ^{1,2}	0 to +10
Oil swell, ASTM Oil No. 3, 70 hr at 212°F (100°C), weight change	ASTM D471	45% max.
Ozone resistance, 20% strain, 300 ppm in air, 70 hr at 104°F (40°C)	ASTM D1149 (Modified) ³	No cracks
Low-temperature stiffening, 7 days at 14°F(10°C), hardness, Durometer A, points change	ASTM D2240 (Modified) ^{1,2}	0 to +15

Compression set, 70 hr at 212°F (100°C)

ASTM D395 Method B 40% max.
(Modified)¹

¹The term *modified* relates to the specimen preparation. The use of the strip seal as the specimen source requires that more plies than specified in either modified test procedure be used. Such specimen modification shall be agreed upon by the purchaser and producer or supplier prior to testing.

²The hardness test shall be performed with the durometer in a durometer stand as specified in ASTM D2240.

³Test in accordance with ASTM D518, Procedure A. Ozone concentration is expressed in pphm.

1. **Steel portion of expansion dam** shall conform to the requirements of ASTM A709, Grade 36.
 2. **Deformed reinforcing steel bars** shall conform to the requirements of ASTM A615, Grade 60.
 3. **Lubricant adhesive** shall be a one-part moisture-curing polyurethane compound conforming to the requirements of ASTM D4070.
 4. **Fabric reinforcement** shall be nonwicking woven polyester material.
 5. **Bolts, nuts, and washers** shall conform to the requirements of ASTM A276, Type 304 Stainless Steel.
 6. **Flathead screws** shall conform to the requirements of ASTM F 738, Type 304 Stainless Steel.
 7. **Stud anchors** shall conform to the requirements of Section 226.02(d).
 8. **Special conditions such as doglegs, tees, and crosses in the elastomeric strip seal gland** shall be shop fabricated in a mold under heat and pressure.
- (k) **Pressure relief joint material** shall conform to the requirements of ASTM D3204.
- (l) **Waterstops** shall conform to the following:
1. **Metal:** Sheet copper shall conform to the requirements of Section 230.
 2. **Nonmetallic Waterstops:** Nonmetallic waterstops shall be manufactured from neoprene or PVC. Manufacturer's shop splices shall be fully vulcanized.
 - a. **Neoprene waterstops** shall be manufactured from a vulcanized elastomeric compound containing neoprene as the sole elastomer and shall conform to the following:
 1. **Material:** Neoprene shall conform to the requirements of Section 230.
 2. **Manufacturing:** Waterstops shall be manufactured in accordance with the requirements of Section 230.
 3. **Installation:** Waterstops shall be installed in accordance with the requirements of Section 230.

Property	Test Procedures	Physical Requirements
Tensile strength	ASTM D412	Min. 2,000 psi
Elongation at break	ASTM D412	Min. 300%
Ozone resistance (20% strain, 100 hr at 100 ± 2°F)	ASTM D1149 (except 100 ± 20 pphm)	No cracks
Oil swell (ASTM No. 3 Oil, 70 hr at 212°F, volume change)	ASTM D471	Max. 80%

After accelerated aging in accordance with the requirements of ASTM D573 for 70 hours at 212 degrees F, the elastomer shall not show a change in tensile strength of more than 15 percent or a change in the elongation at break of more than 40 percent.

- b. **PVC waterstops** shall be manufactured from PVC conforming to the U.S. Corps of Engineers Specification CRD-C 572 and shall conform to the ozone resistance as required for neoprene waterstops. A certificate certifying compliance with the performance requirements specified under paragraph 6 of CRD-C 572 shall be furnished with the test sample supplied.
- (m) **Traffic loop sealant material** shall be an epoxy-resin system, a polyester system, or rubberized asphalt designed specifically to conform to the physical properties for sealing traffic loop pavement cuts. The system shall bond to either hydraulic cement concrete or asphalt concrete, be unaffected by environmental conditions, and have a dielectric strength sufficient to allow the traffic loop to operate as intended. The viscosity of the mixture shall be such that the mixture is easily pourable into the saw slot and sufficiently flowable to encase the electrical wiring.
1. **The epoxy-resin system** shall be a two-component material conforming to the following based on the epoxy without sand, except for the cure time requirement:

Property	Test Procedures	Physical Requirements
Pot life at 77°F	ASTM C881, Para. 11.2	Min. 12 min
Initial cure time at 77°F		Max. 60 min
Hardness, Shore D	ASTM D2240	25–65
Elongation	ASTM D638	Min. 50%
Water absorption (24 hr)	ASTM D570	Max. 0.5%
3% NaCl absorption (24 hr)	ASTM D570	Max. 0.5%
ASTM No. 3 Oil absorption (24 hr)	ASTM D570	Max. 0.1%
Gasoline absorption (24 hr)	ASTM D570	Max. 1.0%

The sand used in the epoxy-resin system shall conform to the following grading requirements:

Sieve No.	% Passing
16	100
30	95 ± 5
100	Max. 10
200	Max. 3

2. **The polyester system** shall be a two-component material conforming to the following:

Property	Test Procedures	Physical Requirements
Pot life at 77°F	ASTM C881, Para. 11.2	Min. 12 min
Initial cure time at 77°F		Max. 45 min
Hardness, Shore D	ASTM D2240	25–65
Elongation	ASTM D638	Min. 15%
Water absorption (24 hr)	ASTM D570	Max. 0.2%
3% NaCl absorption (24 hr)	ASTM D570	Max. 0.2%
ASTM No. 3 Oil absorption (24 hr)	ASTM D570	Max. 0.02%
Gasoline absorption (24 hr)	ASTM D570	Max. 0.8%

3. **Rubberized asphalt** (two-component) shall conform to the following:

Property	Test Procedures	Physical Requirements
Pot life at 77°F		Min. 25 min
Initial cure time at 77°F		Max. 60 min
Hardness, Shore A	ASTM D2240	Max. 20
Flow at 140°F (5 hr)	ASTM D1851	No flow
Bond at 0°F (3 cycles)	ASTM D1851	Min. 50% of original width
Water absorption (72 hr)		Max. 0.1%
ASTM No. 3 Oil absorption (24 hr)		Max. 0.1%

SECTION 213—DAMP-PROOFING AND WATERPROOFING MATERIALS

213.01—Description

These specifications cover materials, generally asphalt based, that are intended to prevent or delay the passage of water, usually through a section of hydraulic cement concrete.

213.02—Detail Requirements

- (a) **Asphalt** shall conform to the requirements of ASTM D312 Type II and shall be free of asbestos. Primer shall conform to the requirements of AASHTO M140, Types SS-1h, QS-1H, or AASHTO M208, Types CSS-1h, CQS-1h.

- (b) **Fabric** shall conform to the requirements of AASHTO M288. When cotton fabric is used, it shall be saturated with asphalt. Glass fiber shall conform to the requirements of ASTM D1668.
- (c) **Joint sealers** for horizontal joints shall be an asphalt cement, viscosity grade AC-40, conforming to the requirements of Section 210. Sealers for vertical joints shall have fiber added, 20 percent by weight. Fiber and asphalt shall be mixed by the manufacturer to ensure a uniform mixture.
- (d) **Membrane** shall conform to the requirements of ASTM D6153.

SECTION 214—HYDRAULIC CEMENT

214.01—Description

These specifications cover cements that harden when mixed with water. The various types have special characteristics to be used as denoted in other parts of these specifications.

214.02—Detail Requirements

- (a) **Blended hydraulic cement** shall conform to the requirements of AASHTO M240, Type I(P) or Type I(S).
- (b) **Portland cements** shall conform to the requirements of AASHTO M85 except as follows:
 1. The SO_3 content as specified in ASTM C150 will be permitted provided the supporting data specified in ASTM C150 are submitted to the Department for review and acceptance prior to use of the material.
 2. Type I and Type II cement shall contain not more than 1.0 percent alkalis ($\% \text{Na}_2\text{O} + \% 0.658\text{K}_2\text{O}$).
 3. When Type II cement is used, a maximum of 65 percent C_3S will be permitted provided the combined amount of C_3S and C_3A is not more than 73 percent.
 4. When Type III modified cement is used, the C_3A content of the cement shall be not more than 8 percent.
 5. The SiO_2 content shall be at least 20 percent.

SECTION 215—HYDRAULIC CEMENT CONCRETE ADMIXTURES

215.01—Description

These specifications cover materials that are chemical or organic elements that may be added to a concrete mixture, when permitted elsewhere in these specifications, to achieve some desired effect.

215.02—Materials

- (a) **Air-entraining admixtures** shall conform to the requirements of AASHTO M154.
- (b) **Water-reducing and retarding admixtures** shall conform to the requirements of AASHTO M194, Type D, and shall be free from water-soluble chlorides.

Use of water-reducing and retarding admixtures that have not been tested for compatibility with the brand, type, source, and quantity of cement proposed for use will not be permitted until tests have been performed in accordance with the requirements of VTM-16 and the test results conform to the requirements of Table I therein.

- (c) **Water-reducing admixtures** shall conform to the requirements of AASHTO M194, Type A, and shall be free from water-soluble chlorides.
- (d) **Accelerating admixtures** shall conform to the requirements of AASHTO M194, Type C or E.
- (e) **High-range water-reducing and high-range water-reducing and retarding admixtures** shall conform to the requirements of AASHTO M194, Type F or G, and shall be free from water-soluble chlorides.
- (f) **Calcium chloride** shall conform to the requirements of AASHTO M144, Type 2.
- (g) **Fly ash** shall conform to the requirements of Section 241.02(a).
- (h) **Granulated iron blast-furnace slag** shall conform to the requirements of ASTM C989, Grade 100 or 120.
- (i) **Silica fume** shall conform to the requirements of AASHTO M307.
- (j) **Corrosion inhibitor** shall contain a minimum 30 percent solution of calcium nitrate or other approved material.

215.03—Detail Requirements

Approved admixture(s) shall be used in concrete in the proportions recommended by the manufacturer to obtain the optimum effect where seasonal, atmospheric, or job conditions dictate its use.

Only admixtures (a) through (e) that appear on the Department's approved products list shall be used. Initial approval will be based on independent laboratory data submitted by the manufacturer. Follow-

ing initial approval of concrete admixtures, the manufacturer shall annually certify to the Engineer in writing that the material currently being furnished is identical in both composition and chemical concentrations with the material for which the laboratory tests were performed. If the Contractor proposes to use an admixture that differs in concentration from the acceptance sample, a certificate shall be required from the manufacturer stating that the chemical composition of the material is essentially the same as that of the approved mixture.

When placing concrete by pumping is authorized, the use of pump-aid admixtures approved by the Department will be allowed provided they are used in accordance with the manufacturer's recommendations.

SECTION 216—WATER FOR USE WITH CEMENT OR LIME

216.01—Description

These specifications cover water for use in mixing with cement or lime.

216.02—Detail Requirements

Water shall be clean, clear, and free from oil, acid, salt, alkali, organic matter, or other deleterious substances.

Water that has been approved for drinking purposes may be accepted without testing for use in hydraulic cement concrete, cement, or lime stabilization. Water from other sources and pumping methods shall be approved by the Engineer before use.

The acidity or alkalinity of water will be determined colorimetrically or electrometrically. Water shall have a pH between 4.5 and 8.5. When subjected to the mortar test in accordance with the requirements of AASHTO T26, water shall produce a mortar having a compressive strength of at least 90 percent of a mortar of the same design using distilled water.

Wash water from hydraulic cement concrete mixer operations will be permitted to be reused in the concrete mixture provided it is metered and is 25 percent or less of the total water. The total water shall conform to the acceptance criteria of ASTM C1602, Tables 1 and 2. A uniform amount of wash water shall be used in consecutive batches, with subsequent admixture rates adjusted accordingly to produce a workable concrete conforming to the requirements of the Specifications.

SECTION 217—HYDRAULIC CEMENT CONCRETE

217.01—Description

These specifications cover materials, design criteria, and mixing and testing procedures for hydraulic cement concrete.

217.02—Materials

Hydraulic cement concrete shall consist of hydraulic cement, fine aggregate, coarse aggregate, water, and admixture(s) mixed in the approved proportions for the various classes of concrete by one of the methods designated hereinafter.

The Contractor shall be responsible for the quality control and condition of materials during handling, blending, and mixing operations and for the initial determination and necessary adjustments in the proportioning of materials used to produce the concrete.

- (a) **Cementitious materials** shall be a blend of mineral admixtures and portland cement or a blended cement. The portland cement or Type I(P) or Type I(S) cement shall comply with the requirements of Section 214. Fly ash, granulated iron blast-furnace slag, or silica fume conforming to the requirements of Section 215 shall be used with the cement in a quantity sufficient to limit expansion to a maximum of 0.1 percent at 56 days when tested in accordance with ASTM C-441. If the level of expansion is low enough to permit the use of portland cement only, then the cement shall be Type II. As a portion of the cementitious material, the fly ash content shall be not more than 30 percent for Class F, the ground-granulated blast-furnace slag content shall be not more than 50 percent, and the silica fume content shall be not more than 10 percent.
- (b) **Formulated latex modifier** shall be a nontoxic, film-forming, polymeric emulsion of which 90 percent of the nonvolatiles are styrene butadiene polymers. It shall be homogeneous and uniform in composition and free from chlorides. Latex modifier shall conform to the chemical and physical properties specified hereinafter when tested in accordance with the requirements of FHWA's Report No. RD-78-35. Initial approval of the modifier will be based on an analysis of the results of tests performed by an independent laboratory. After initial acceptance, material will be accepted upon certification subject to periodic testing. A copy of the initial test report shall be submitted to the Department and shall show the following chemical and physical properties:

Property	Value
Butadiene content (%)	30-40
Solids (%)	46-53
pH	8.5-12
Coagulum (%)	Max. 0.10
Surface tension	Max. 50 dynes/cm
Particle size	
Mean Angstrom	1,400-2,500
Median Angstrom	1,400-2,500
Distribution	Unimodal
95% range Angstrom	Max. 2,000
Freeze-thaw stability (% coagulum after 2 cycles)	Max. 0.10
Concrete slump	Greater than standard
Concrete air content	Max. 9%
Time for 50% slump loss	±25% standard
Concrete compressive strength (24 hr and 28 days)	Min. 75% standard
Compressive strength loss (28-42 days)	Max. 20%
Concrete flexural strength (24 hr and 28 days)	Greater than standard
Flexural strength loss (28-42 days)	Max. 25%

Property	Value
Bond strength/slant shear (% monolithic latex concrete cylinder)	Min. 45
Deicer scaling (50 cycles)	
Median grading	Max. 3
Worst rated	Below 5
Chloride permeability (95% absorbed)	
1/16-1/2 in (% Cl ⁻)	Max. 0.320
1/2-1 in (% Cl ⁻)	Max. 0.064

Values for viscosity and density spectrographs of the solid portion and volatile portion shall be provided in the report.

- (c) **Fine aggregate** shall conform to the requirements of Section 202 for Grading A.
- (d) **Coarse aggregate** shall be stone, air-cooled blast-furnace slag, or gravel conforming to the requirements of Section 203 for the class of concrete being produced.
- (e) **Water** shall conform to the requirements of Section 216.
- (f) **Admixtures** shall conform to the requirements of Section 215.
- (g) **White portland cement concrete** shall conform to the requirements herein except as follows:
 1. **Cement** shall be white portland cement conforming to the requirements of Section 214 for Type I portland cement except that it shall contain not more than 0.55 percent by weight of Fe₂O₃.
 2. **Fine aggregate** shall consist of clean, hard, durable, uncoated particles of quartz composed of at least 95 percent silica; shall be free from lumps of clay, soft or flaky material, loam, organic material, or other deleterious material; and shall conform to the requirements of Section 202. It shall contain not more than 3 percent inorganic silt by actual dry weight when tested in accordance with the requirements of AASHTO T11. Stone sands that produce an acceptable white concrete may also be used.
 3. **Coarse aggregate** shall be crushed stone or crushed or uncrushed gravel conforming to the requirements of Section 203.
- (h) **Fly ash** shall conform to the requirements of Section 241.
- (i) **Granulated iron blast-furnace slag** shall conform to the requirements of Section 215.
- (j) **Concrete to which a high-range water reducer is to be added** shall conform to the requirements of Table II-17. Concrete shall be mixed 70 to 100 revolutions at mixing speed.
- (k) **Silica fume** shall conform to the requirements of Section 215.

217.03—Handling and Storing Materials

- (a) **Aggregate** shall be kept separated by size until batched. Aggregates shall be clean and shall be maintained in at least a saturated, surface-dry condition.

Fine aggregate that has been washed shall not be used within 24 hours after being placed in the stockpile or until surplus water has disappeared and the material has a consistent free moisture content. Stockpiles shall be located and constructed so that surplus water will drain from stockpiles and the batcher.

- (b) **Cement** that is reclaimed or that shows evidence of hydration, such as lumps or cakes, shall not be used.

Loose cement shall be transported to the mixer either in tight compartments for each batch or between the fine and coarse aggregate. Cement in original shipping packages may be transported on top of the aggregates, with each batch containing the number of bags required.

- (c) **Latex modifier** shall be kept in enclosures that will protect it from exposure to temperatures below 40 degrees F or above 85 degrees F. Containers of latex modifier shall be protected from direct sunlight.
- (d) **Admixtures** shall be stored and handled so that contamination and deterioration will be prevented. Liquid admixtures shall not be used unless thoroughly agitated. Admixtures that are frozen or partially frozen shall not be used.
- (e) **Aluminum forms, chutes, buckets, pump lines, and other conveying devices** shall not be used if the aluminum comes in contact with concrete.

217.04—Measurement of Materials

Measuring devices shall be subject to the approval of the Engineer.

- (a) **Stationary Production Plant:**

1. **Cement** shall be measured by weight. Cement in standard packages of 94 pounds net per bag need not be weighed, but bulk cement and fractional packages shall be weighed within an accuracy of 1 percent.
2. **Mixing water** shall be measured by volume or weight. The water-measuring device shall be readily adjustable and capable of delivering the required amount. Under all operating conditions, the device shall have an accuracy of within 1 percent of the quantity of water required for the batch.
3. **Aggregates** shall be measured by weight within an accuracy of 2 percent. Fine and coarse aggregate shall be weighed separately. Prior to mixing concrete, the moisture content of aggregates shall be determined and proper allowance made for the water content. The moisture content shall be determined prior to the start of mixing and thereafter as changes occur in the condition of aggregates. The Contractor shall per-

form moisture determinations and tests for slump and air content and provide necessary testing equipment.

4. **Admixtures** shall be added within a limit of accuracy of 3 percent and dispensed to the mixing water by means of an approved, graduated, transparent, measuring device before they are introduced into the mixer. If a high-range water reducer is to be used, it shall be added in accordance with the manufacturer's recommendations. If more than one admixture is to be used, they shall be released into the mixing water in sequence rather than at the same instant. Once established, the sequence of dispensing admixtures shall not be altered. Admixtures shall be used in accordance with the requirements of the manufacturer's recommendations. However, when the amount of admixture required to give the specified results deviates appreciably from the manufacturer's recommended dosage, use of the material shall be discontinued.

- (b) **Mobile Production Plant:** Aggregates, cement, and water shall be measured by weight or volume. If ingredients are measured by volume, the Contractor shall furnish, at his expense, approved scales and containers suitable for checking the calibration of the equipment's measuring system. The manufacturer's recommendations shall be followed in operating the equipment and calibrating the gages and gate openings. Mixing water shall be measured by a calibrated flow meter. The introduction of mixing water to the mixer shall be properly coordinated with the introduction of cement and aggregates. Ingredients shall be proportioned within the following tolerances, which are based on the volume/weight relationship established by calibration of the measuring devices:

Ingredient	Tolerance
Cement	0 to +4%
Fine aggregate	±2%
Coarse aggregate	±2%
Admixtures	±3%
Water	±1%

Tolerances will be applied to approved mixture design quantities.

Means shall be provided whereby samples of the various ingredients can be taken from the feed prior to blending and mixing to test the calibration of the equipment.

217.05—Equipment

Equipment and tools necessary for handling materials and performing all parts of the work shall be as approved by the Engineer.

- (a) **Batching Equipment:** Bins with separate compartments for fine aggregate and for each required size of coarse aggregate shall be provided in the batching plant. Bins for bulk cement shall be arranged so that cement is weighed on a scale separate from those used for other materials and in a hopper free and independent of hoppers used for weighing aggregates. The weighing hopper shall be properly sealed and vented to preclude dusting during operation. Each compartment shall be designed to discharge aggregate efficiently and freely into the weighing hopper. A means of control shall be provided so that material may be added slowly and shut off with precision. A port or other opening shall be provided to remove any

overrun of any of the several materials from the weighing hopper. Weighing hoppers shall be constructed to prevent accumulation of materials and to discharge fully.

Scales used for weighing aggregates and cement shall be approved and sealed in accordance with the requirements of Section 109. At least ten 50-pound test weights shall be made available at each plant to verify the continued accuracy of the weighing equipment. Weights shall be calibrated by the Virginia Department of Agriculture and Consumer Services or other approved agencies when new and whenever there is visible evidence that they have been damaged.

When beam scales are used, provision shall be made for indicating to the operator that the required load in the weighing hopper is being approached. The indicator shall indicate at least the last 200 pounds of load. Weighing and indicating devices shall be in full view of the operator while the hopper is charged, and the operator shall have convenient access to all controls.

- (b) **Mixers and Agitators:** Mixers may be stationary or truck mixers. Agitators may be truck mixers or truck agitators. Each mixer and agitator shall have a metal plate(s) attached in a prominent place by the manufacturer on which the following are marked: the various uses for which the equipment is designed, capacity of the drum or container in terms of the volume of mixed concrete, and speed of rotation of the mixing drum or blades. Each stationary mixer shall be equipped with an approved timing device that will not permit the batch to be discharged until the specified mixing time has elapsed. Each truck mixer shall be equipped with an approved counter by which the number of revolutions of the drum or blades may be readily verified.

The mixer shall be capable of combining ingredients of concrete into a thoroughly mixed and uniform mass and of discharging concrete with a satisfactory degree of uniformity.

The agitator shall be capable of maintaining mixed concrete in a thoroughly mixed and uniform mass and of discharging concrete within a satisfactory degree of uniformity.

Mechanical details of the mixer or agitator, such as the water measuring and discharge apparatus, condition of the blades, speed of rotation of the drum, general mechanical condition of the unit, and cleanliness of the drum, shall be checked before use of the unit is permitted. Upon request by the Engineer, consistency tests of individual samples at approximately the beginning, midpoint, and end of the load shall be conducted. If consistency measurements vary by more than 2 inches for slump between high and low values, the mixer or agitator shall not be used until the condition is corrected.

- (c) **Mobile Production Plants:** The Contractor may produce Class A3 general use hydraulic cement concrete for incidental construction items from a mobile production plant. Mobile production plants will not be permitted to produce concrete used in bridges, except over-lays; box culverts; pavements, except patching; or retaining walls. If the Contractor elects to use a mobile production plant as permitted, the equipment requirements specified hereinbefore will not apply and the concrete shall be mixed at the point of delivery by a combination materials transport and mixer unit conforming to the following:
1. The unit shall be capable of carrying ingredients needed for concrete production in separate compartments and of mixing ingredients at the point of delivery. The unit shall be equipped with calibrated proportioning devices to vary mixture proportions of

dry ingredients and water. The unit shall be capable of changing the slump at any interval of continuous discharge of concrete.

2. The mixing mechanism shall be a part of the transportation unit carrying dry ingredients. The mixer may be any type capable of combining ingredients of concrete into a thoroughly mixed and uniform mass and of discharging concrete with a satisfactory degree of uniformity within the specified time of mixing.
3. Each unit shall have a metal plate(s) attached in a prominent place by the manufacturer on which the following are plainly marked: the gross volume of the transportation unit in terms of mixed concrete, discharge speed, and weight-calibrated constant of the machine in terms of an indicator revolution counter.
4. During discharge, the consistency, determined by the slump cone method (ASTM C143), of representative samples taken from the discharge of the mixer at random intervals shall not vary by more than 1 inch.

217.06—Classification of Concrete Mixtures

Classes and uses of concrete are specified in Table II-17.

217.07—Proportioning Concrete Mixtures

The Contractor is responsible for having a Certified Concrete Batcher or a Certified Concrete Plant Technician present during batching operations; a Certified Concrete Field Technician shall be present during placing operations.

A Certified Concrete Plant Technician is that person who is capable of performing adjustments to the proportioning of materials used to produce the specified concrete should adjustments become necessary.

A Certified Concrete Batcher is that person who actually performs the batching operation. He shall never initiate adjustment and will be permitted to implement adjustment only at the direction of the Certified Concrete Plant Technician unless his certification has this special authorization.

A Certified Concrete Field Technician is that person who is responsible for quality control of concrete work at the project site. The Contractor shall have at least one Certified Concrete Field Technician on the project for single or multiple incidental concrete placements. The Contractor shall have at least one Certified Concrete Field Technician present at each site during the placement of pavements, bridge decks, bridge piers and abutments, box culverts, and any placement of 50 or more cubic yards.

The Certified Concrete Field Technician shall provide control over methods used for discharging, conveying, spreading, consolidating, screeding, finishing, texturing, curing, and protecting the concrete. Deficiencies in conformance to specification requirements and good concreting practices shall be corrected as soon as they begin to occur.

The concrete producer shall plan batching operations so that delays do not occur because of the absence of certified personnel.

Concrete shall be proportioned to secure the strength and durability required for the pavement or the part of the structure in which it is to be used.

Prior to mixing concrete, the Contractor shall submit, or shall have his supplier submit, for approval concrete mixture design(s) conforming to the specifications for the class of concrete specified.

The Contractor shall furnish and incorporate an approved water-reducing and retarding admixture in bridge deck concrete and in other concrete when conditions are such that the initial set may occur prior to completion of approved finishing operations. An approved water-reducing admixture shall be furnished and incorporated in concrete when necessary to provide the required slump without exceeding the maximum water/cement ratio and shall be used in bridge deck concrete when the requirement for a water-reducing and retarding admixture is waived by the Engineer. The Contractor shall demonstrate that use of the admixture will not cause segregation. The two admixtures shall not be used together in the same concrete batch unless tests indicate the admixtures are compatible in accordance with the requirements of Section 215.02(b). Costs for admixture(s) shall be included in the contract unit price for the respective concrete item.

Concrete shall be air entrained. The air content shall conform to the requirements of Table II-17.

TABLE II-17
Requirements for Hydraulic Cement Concrete

Class of Concrete	Design Min. Laboratory Compressive Strength at 28 Days (f'c) (psi)	Aggregate Size No.	Nominal Max. Aggregate Size (in)	Min. Grade Aggregate	Min. Cement Content (lb/yd ³)	Max. Water (lb water/lb cement)	Consistency (in of slump)	Air Content (%) ¹
A5 Prestressed and other special designs ²	5,000	57 or 68	1	A	635	0.40	0-4	4 1/2 ± 1 1/2
A4.5 General	4,500	57	1	A	635	0.45	2-4	6 1/2 ± 1 1/2
A4 General	4,000	57	1	A	635	0.45	2-4	6 1/2 ± 1 1/2
A4 Posts and rails ³	4,000	7	1/2	A	635	0.45	2-5	7 ± 2
A3.5 General	3,500	57	1	A	588	0.49	1-5	6 ± 2
A3 General	3,000	57	1	A	588	0.49	1-5	6 ± 2
A3 Paving	3,000	57	1	A	564	0.49	0-3	6 ± 2
B2 Massive or lightly reinforced	2,200	57	1	B	494	0.58	0-4	4 ± 2
C1 Massive unreinforced	1,500	57	1	B	423	0.71	0-3	4 ± 2
T3 Tremie seal	3,000	57	1	A	635	0.49	3-6	4 ± 2
Latex hydraulic cement concrete ⁴	3,500	7 or 8	1/2	A	658	0.40	4-6	5 ± 2
Silica fume concrete	5,000	7 or 8	1/2	A	658 ⁵	0.40	4-7	6 ± 2

¹When a high-range water reducer is used, the upper limit for entrained air may be increased by 1% and the slump shall not exceed 7 inches.

²When Class A5 concrete is used as the finished bridge deck riding surface, or when it is to be covered with asphalt concrete with or without waterproofing, the air content shall be 5 1/2 ± 1 1/2%.

³When necessary for ease in placement, aggregate No. 7 shall be used in concrete posts, rails, and other thin sections above the top of bridge deck slabs.

⁴The latex modifier content shall be 3.5 gallons per bag of cement. Slump shall be measured approximately 4 1/2 minutes after discharge from the mixer.

⁵Minimum 7% silica fume replacement by weight of the total cementitious material.

Note: The Contractor may substitute a higher class of concrete for that specified at his expense.

Except for latex hydraulic cement concrete, the quantities of fine and coarse aggregates necessary to conform to these specifications with regard to consistency and workability shall be determined by the method described in ACI 211.2 or ACI 211.1 except that proportions shall be computed on the absolute volume basis and the 10 percent adjustment allowed in Table 5.3.6 will not be permitted. The actual quantities used, as determined by the methods described herein, shall not deviate more than ± 5 percent from such quantities.

For latex hydraulic cement content, the dry weight ratio of cement/fine aggregate/coarse aggregate shall be 1:2.5:2. A maximum adjustment of 10 percent may be made in aggregate weights, as approved by the Engineer, to compensate for grading changes and variable specific gravity.

Batch quantities shall be adjusted during the course of the work to compensate for changes in workability caused by differences in characteristics of aggregates and cements within the specification requirements. Such adjustments shall be made only by the Contractor and shall not change the yield.

If concrete cannot be obtained with the required workability or consistency or with the maximum design water content with the materials furnished, the Contractor shall make changes to secure the desired properties subject to the limiting requirements specified in Table II-17 and the approval of the Engineer. When the void content of the fine aggregate is more than 50.5 percent and the concrete does not have the desired properties, the Contractor shall use a fine aggregate having a void content of less than 50.5 percent. In lieu of changing the fine aggregate, the Contractor may take one or more of the following actions:

- (a) Use an approved water-reducing admixture.
- (b) Increase the cement content.
- (c) Change the source of coarse aggregate.
- (d) In hot weather, add ice or otherwise reduce the temperature to increase the workability.
- (e) Submit other recommendations to the Engineer for approval.

However, when any of the options is exercised, the Contractor shall make trial batches under the observation of the Engineer to verify that concrete of the required workability and consistency is obtained within the specified water content. At least one trial batch shall be made with the concrete temperature at approximately 90 degrees F to verify that the concrete mixture has sufficient workability and consistency without exceeding the specified water content. When the fineness modulus of the fine aggregate changes more than 0.2 from the original design and the concrete does not have the desired properties, the concrete mixture shall be redesigned. Costs incurred because of adjustments of concrete mixture design(s) and for trial batches shall be borne by the Contractor, and no additional compensation will be made.

217.08—Acceptance

- (a) **Air and Consistency Tests:** Air and consistency tests will be performed by the Department prior to discharge of concrete into forms to ensure that specification requirements are consistently being complied with for each class of concrete. The sample secured for the tests will be taken after at least 2 cubic feet of concrete has been discharged from the delivery vehicle. The Contractor shall provide a receptacle conforming to the requirements of ASTM

C31, Section 5.9, for the Department's use in obtaining its sample. If either determination yields a result that is outside the allowable range for air content or consistency, the following procedures will be used:

1. The Engineer will immediately perform a recheck determination. If the results confirm the original test results, the load will be rejected.
2. The Contractor's representative will be immediately informed of the test results.
3. The Contractor's representative shall notify the producer of the test results through a pre-established means of communication.

The Engineer may perform any additional tests deemed necessary and reject all remaining material that fails the tests.

Entrained air content will be determined in accordance with the requirements of ASTM C231 or ASTM C173. Acceptance or rejection will be based on the results obtained from these tests.

In general, a mixture that contains the minimum amount of water consistent with the required workability shall be used. Consistency will be determined in accordance with the requirements of ASTM C143. Adding cement to loads previously rejected for excessive water content or consistency will not be permitted.

- (b) **Strength Tests:** The 28-day strengths specified in Table II-17 are the strengths used in the design calculations. The Engineer will verify design strengths by tests made during the progress of the work in accordance with the requirements of ASTM C39, ASTM C31, or ASTM C42. If the test results do not conform to the strength requirements specified in Table II-17, immediate steps shall be taken to adjust the design mixture and an investigation will be initiated to determine the acceptability of the concrete.

The Contractor shall provide a storage chamber at his expense for temporary storage of the Department's concrete cylinders. The chamber shall be designed to maintain test cylinders in a continuously moist condition within a temperature range of 60 degrees F to 80 degrees F and shall be equipped with a maximum/minimum thermometer. The chamber shall be located near the concrete placement site in an area where test cylinders will not be subject to vibration and shall be of sufficient size or number to store, without crowding or wedging, the required number of test cylinders as determined by the Contractor based on his plan of operations.

When use of high-early-strength hydraulic cement concrete is required, it shall conform to the requirements specified in Table II-17 except that the 28-day strength shall be obtained in 7 days. Up to 800 pounds per cubic yard of Type I or Type II cement may be used to produce high-early-strength concrete in lieu of using Type III modified cement.

217.09—Mixing

The method of mixing shall be approved by the Engineer prior to the start of concrete work.

The volume of concrete mixed per batch shall be at least 15 but not more than 110 percent of the mixer's rated capacity.

Concrete that becomes nonplastic, unworkable, or outside the limits of the slump specified shall not be used. Retempered concrete shall not be used. Concrete delivery shall be regulated so that placement is at a continuous rate. Intervals between deliveries of batches shall not be so great as to allow concrete in place to begin initial set.

- (a) **Mixing at Job Site:** Concrete shall be mixed in a batch mixer designed to ensure a uniform distribution of materials throughout the mass. When bag cement is used, batches shall be proportioned on the basis of integral bags of cement.

Mixing shall be performed in accordance with the requirements (b)3 herein.

Upon the cessation of mixing for more than 30 minutes, the mixer shall be thoroughly cleaned.

- (b) **Ready-Mixed Concrete:** Ready-mixed concrete shall be delivered to the designated point ready for use.

Each load of transit or shrink-mixed concrete shall be accompanied by Form TL-28 issued by the batcher or technician. The form shall be delivered to the Inspector at the site of the work. Loads that do not carry such information or that do not arrive in satisfactory condition shall not be used.

Upon cessation of mixing for more than 30 minutes, the mixer shall be thoroughly cleaned.

Each batch of concrete shall be delivered to the site of work and discharged within the allotted time. The allotted time will begin the instant the cement is introduced into the mixture. Times given for retarded concrete are provided to accommodate the physical limitations of a formed section or scattered locations of small increment placements and shall not be used to accommodate slow and noncontinuous placements caused by poor planning or scheduling, inadequate equipment or personnel, or excessive haul distances.

Maximum Time Between Introduction of Cement to Mix and Completion of Discharge

Equipment	Concrete Temperature		
	Up to 80°F	80 through 90°F	Above 90°F
Agitator Type Haul Equipment			
Retarded	2 1/2 hr	2 hr	1 1/2 hr
Unretarded	1 1/2 hr	1 1/4 hr	1 hr
Nonagitator Type Haul Equipment			
All Concrete	1 hr	3/4 hr	1/2 hr

Mixing and delivery shall be in accordance with the following:

1. **Transit mixing:** Concrete shall be mixed in a truck mixer. Mixing shall begin immediately after all ingredients are in the mixer and shall continue for at least 70 but not more than 125 revolutions of the drum or blades at the rate of at least 14 but not more than 20 revolutions per minute.

Additional rotations of the drum or blades shall be at the rated agitating speed. The mixer shall be operated within the capacity and speed of rotation designed by the manufacturer.

2. **Shrink mixing:** Materials, including water, shall be partially mixed in a stationary mixer for at least 30 seconds. Mixing shall be completed in a truck mixer with at least 60 but not more than 100 revolutions of the drum or blades at the rated mixing speed. Additional rotations of the drum or blades shall be at the rated agitating speed. Mixers shall be operated within the capacity and speed of rotation designated by the manufacturer of the equipment.
3. **Central mixing:** Concrete shall be completely mixed in a stationary mixer and transported in the agitator equipment to the point of delivery. Use of nonagitator equipment will be approved only when the plant is in the immediate vicinity of the project.

Mixing time for mixers having a capacity of 1 cubic yard or less shall be at least 60 seconds. Mixing time for mixers having a capacity of more than 1 but less than 10 cubic yards shall be at least 75 seconds. Mixing times for mixers having a capacity of more than 10 cubic yards shall be as determined by the Engineer. Performance tests shall be conducted in accordance with the requirements of VTM-17 by an approved commercial laboratory at the Contractor's expense. Lesser times will be approved if the requirements of VTM-17 are conformed to. In any event, mixing time shall be not less than 40 seconds.

The requirements of VTM-17 shall not be construed as a nullification of the requirements of Table II-17. If subsequent evaluation check tests indicate that the reduced mixing time is not satisfactory, the Contractor shall reestablish the necessary mixing time.

Concrete mixed for less than the specified time will be rejected. Mixing time starts when solid materials are in the mixing compartment and ends when any part of the concrete begins to discharge. The mixer shall be operated at the drum speed specified on the nameplate of the approved mixer.

Bodies of nonagitator equipment used to transport concrete shall be smooth, mortar tight, non-aluminum metal containers capable of discharging concrete at a controlled rate without segregation. Upon discharge of concrete, the body of the equipment shall be free from concrete. Concrete shall be delivered to the work site in a thoroughly mixed and uniform mass. Upon the request of the Engineer, consistency tests of individual samples at approximately the beginning, midpoint, and end of the load shall be conducted. If consistency measurements vary by more than 2 inches for slump between high and low values, mixer or agitator equipment shall be used in lieu of nonagitator equipment.

- (c) **Automatic Mobile Continuous Mixers:** Mobile continuous mixers shall be calibrated to proportion the mixture accurately and shall have been certified within 60 days prior to use on the project for the type of material specified. Certifications will be valid for 6 months or until the source of materials changes or the grading or moisture changes significantly so as to affect the consistency of the concrete. Evaluation and certification will be performed by the Department or an approved testing agency to determine that the true yield is within a

tolerance of ± 1.0 percent. A recording meter, visible at all times and equipped with a ticket printout, shall indicate the calibrated measurement.

- (d) **Hand Mixing:** Hand mixing will be permitted only in case of emergency and with permission. Batches shall be not more than 1/2 cubic yard and shall be mixed in a watertight container in a manner approved by the Engineer. Ingredients shall be measured by placing them in any suitable, rigid container in the volumetric proportions of 1 part cement to 2 parts fine aggregate to 2 1/2 parts coarse aggregate. The container shall be filled and leveled with each ingredient to ensure the proportions specified as nearly as possible. Water shall be added to produce a slump of not more than 3 inches.

217.10—Placement Limitations

The Contractor shall be responsible for the quality of concrete placed in any weather or atmospheric condition. At the time of placement, concrete shall have a temperature in accordance with the following:

- (a) **Class A3 general use concrete used in the construction of incidental items specified in Division V, except retaining walls,** shall have a temperature of at least 40 degrees F but not more than 95 degrees F.
- (b) **Class A3 paving concrete placed by the slipform method and containing an approved water reducer** shall have a temperature of at least 40 degrees F but not more than 95 degrees F.
- (c) **Concrete used in the construction of bridge decks** shall have a temperature of at least 40 degrees F but not more than 85 degrees F.
- (d) **Retaining walls and other concrete not specified in (a), (b), or (c) herein** shall have a temperature of at least 40 degrees F but not more than 90 degrees F.

In cold weather, water and aggregates may be heated to not more than 150 degrees F to maintain concrete at the required temperature. The heating apparatus shall be such that materials will be heated uniformly and the possibility of the occurrence of overheated areas that might damage materials will be precluded. Steam shall not come in contact with aggregates. Cement shall not be heated. Heating equipment or methods that alter or prevent entrainment of the required amount of air in concrete shall not be used. Materials containing frost, lumps, crusts, or hardened material shall not be used.

In hot weather, aggregates or the mixing water shall be cooled as necessary to maintain the temperature of the concrete within the specified maximum.

SECTION 218—HYDRAULIC CEMENT MORTAR AND GROUT

218.01—Description

These specifications cover hydraulic cement mortar and grout used in bonding units together, filling voids, and making surface repairs.

218.02—Materials

- (a) **Hydraulic cement** shall conform to the requirements of Section 214.
- (b) **Fine aggregate** shall conform to the requirements of Section 202.
- (c) **Water** shall conform to the requirements of Section 216.
- (d) **Admixtures** shall conform to the requirements of Section 215.

218.03—Detail Requirements

Hydraulic cement mortar and grout shall consist of a mixture of hydraulic cement, fine aggregate, water, and admixtures as specified herein.

Hydraulic cement mortar and grout shall contain from 3 to 7 percent entrained air. Air-entrained hydraulic cement may be used. Hydraulic cement mortar and grout shall be mixed with the minimum amount of water necessary to obtain the required consistency.

- (a) **Hydraulic cement mortar** shall consist of 1 part hydraulic cement, 2 1/2 parts fine aggregate by weight, and sufficient water to produce a stiff mixture. Grading C fine aggregate shall be used.
- (b) **Nonshrink mortar** shall consist of 1 part hydraulic cement, 2 parts fine aggregate by weight, a set retarder or other admixture that will reduce the amount of required mixing water, and sufficient water to produce a stiff mixture. Grading C fine aggregate shall be used.
- (c) **Hydraulic cement grout** shall consist of 1 part hydraulic cement, 2 parts fine aggregate by weight, and sufficient water to produce a free-flowing mixture. Grading A or C fine aggregate shall be used.
- (d) **High-strength grout and mortar** shall consist of a prepackaged, nonshrink hydraulic cement mixture conforming to the requirements of ASTM C1107 modified by the following: the grout/mortar shall develop a 7-day compressive strength of at least 4,000 pounds per square inch when tested in accordance with the requirements of ASTM C109 and a 7-day bond strength of at least 1,000 pounds per square inch when tested in accordance with the requirements of VTM-41, except that epoxy shall not be used to develop the bond.

SECTION 219—RIGHT-OF-WAY MONUMENTS

219.01—Description

These specifications cover concrete and metal markers used to designate right-of-way boundaries.

219.02—Detail Requirements

Right-of-way monuments shall be manufactured from reinforced concrete or metal conforming to the dimensions shown on the standard drawings and in accordance with these specifications.

- (a) **Concrete Monuments:** Concrete shall be Class A3 conforming to the requirements of Section 217 except that the use of Type I cement and a change in the aggregate size will be permitted.

Steel reinforcement shall conform to the requirements of Section 223 and shall be placed as shown on the standard drawings.

Monuments shall be cast in one piece with smooth and uniform surfaces.

Monuments shall withstand a cracking load of at least 4,000 pounds and a destruction load of 5,000 pounds when tested transversely on a 24-inch span and shall have an absorption value of not more than 10 percent. Tests will be performed in accordance with the requirements of AASHTO T177.

- (b) **Metal Monuments:** Material for steel pins shall conform to the requirements of Section 223.

Material for locator posts shall conform to the requirements of Section 226 or Section 229.

Steel posts or pins shall be galvanized in accordance with the requirements of ASTM A123.

SECTION 220—CONCRETE CURING MATERIALS

220.01—Description

These specifications cover materials used to maintain the humidity and temperature of freshly placed concrete to ensure satisfactory hydration and proper hardening of the concrete.

220.02—Detail Requirements

Concrete curing materials shall consist of waterproof paper, polyethylene (PE) film, a combination of burlap and PE film, liquid membrane-forming compound, or water. Concrete curing materials shall be free from impurities that may be detrimental to the surface of concrete.

- (a) **Waterproof paper** shall conform to the requirements of AASHTO M171. One side shall be composed of white, light-reflecting paper.
- (b) **PE film** shall conform to the requirements of AASHTO M171 except that its nominal thickness shall be 3.0 mils. The thickness at any point shall be at least 2.5 mils.
- (c) **Burlap and PE film** may be used in combination. They shall be bonded securely so that they cannot be easily separated in a dry or saturated condition. White PE film shall conform

to the reflectance requirements of AASHTO M171. Burlap shall conform to the requirements of AASHTO M182, Class 3. The combination product shall have a total weight of 11 ounces per square yard with 11 threads of burlap per inch.

- (d) **Liquid membrane-forming compounds** shall be used on concrete masonry except bridge substructure elements. Fugitive dye compounds shall be used on bridge substructure elements. The Contractor shall remove liquid membrane-forming compound from concrete surfaces to which a bonding compound, joint sealer, or waterproofing material is to be applied.

Liquid membrane-forming compounds will be tested in accordance with the requirements of VTM-2 and shall conform to the following:

1. Liquid membrane-forming compounds shall contain an easily dispersed opaque, white, finely ground pigment or a fugitive dye. They shall not react with the components of concrete and shall not contain oils, waxes, or other materials that would prevent bonding of traffic paints. The resulting film shall be continuous, uniform, and free from pinholes, bubbles, or blisters and shall not darken the hardened concrete. The dye shall have sufficient color to be distinctly visible for at least 30 minutes after application and to disappear within 7 days.
 2. The membrane shall not peel. It shall disappear by gradual disintegration from exposure to the elements over a period of at least 30 days but not more than 1 year. Within 60 days after application, the membrane shall be capable of being readily removed by means of steel wire brushes or another abrasive that will not damage the concrete surface.
 3. When applied by pressure spray to a troweled, vertical, damp concrete surface at the rate specified, material shall adhere to the surface in a continuous, tenacious film without running off or sagging appreciably.
 4. Shipping containers shall identify the trade name of the material and a lot or batch number except for small, locally repackaged containers bearing the Department's seal.
 5. The average moisture loss at 24 hours shall be not more than 0.20 kilograms per square meter of exposed surface. At 72 hours, it shall be not more than 0.30 kilograms per square meter.
 6. When applied to the test specimen, white pigmented material shall have a daylight reflectance of at least 60 percent of that of magnesium oxide.
- (e) **Water** used for curing concrete shall be clean, clear, and free from oil and other deleterious substances and shall have a pH of at least 4.5.

SECTION 221—GUARDRAIL

221.01—Description

These specifications cover material requirements for components of guardrail systems.

221.02—Detail Requirements

Guardrail shall consist of rail or cable elements and fastenings fabricated to develop continuous beam or cable strength when installed.

- (a) **Steel beam guardrail** shall conform to the requirements of AASHTO M180, Class A, Type 1. Where guardrail is to be constructed on curves that have a radius of 150 feet or less, rail elements shall be shop curved to the proper radius, with the roadside of the rail either concave or convex as required.
- (b) **Wire rope (cable)** shall conform to the requirements of AASHTO M30, Type I, Class A.
- (c) **Brackets, turnbuckles, compensating assemblies, and attachment hardware** shall be of sufficient design and section to develop the full strength of the cable guardrail and shall be galvanized in accordance with the requirements of ASTM A153. The spring compensating device shall have a spring constant of 450 ± 50 pounds and shall permit a travel of 6 ± 1 inches.
- (d) **Concrete for precast reinforced concrete posts** shall conform to the requirements of Section 217 for Class A3 except that Type I cement and a smaller size of aggregate may be used.
- (e) **Steel posts** shall be galvanized in accordance with the requirements of AASHTO M111.
 - 1. **Structural rolled shapes** shall conform to the requirements of ASTM A709, Grade 36.
 - 2. **Sheet steel for fabricated shapes** shall conform to the requirements of ASTM A570, Grade 36.
 - 3. **Weld-fabricated shapes** shall conform to the requirements of ASTM A769.
- (f) **Wood posts** shall conform to the requirements of Section 236 and shall be pressure treated.
- (g) **Anchor bolts** shall conform to the requirements of Section 226.02(c) for high-strength bolts.
- (h) **Offset block** shall conform to either of the following:
 - 1. **Offset block shall be made of wood** conforming to the requirements of Section 236 that is pressure treated; or

2. **Offset blocks shall be made from a minimum of 40 percent recycled plastic waste.** Such plastic shall be accumulated from post-consumer and post-industry waste. The material for these blocks shall have a minimum specific gravity of 0.950. The minimum compressive strength of these blocks in the lateral dimension shall be 1,600 pounds per square inch. The maximum water absorption allowed over the theoretical lifetime of the block shall not exceed 5 percent by weight when tested in accordance with ASTM D1037. Block attachment shall be in accordance with the standard drawings for wooden posts, standard GR-2, 2A W-Beam guardrail. The size tolerance in the direction of the bolt hole shall not be more than 1/4 inch. The blocks shall present a neat appearance and have plane surfaces. The blocks shall conform to the dimensions and tolerances listed on the standard drawings.

The manufacturer of the recycled plastic blocks shall provide independent test results showing that the material complies with the velocity, acceleration, and post-impact trajectory requirements of National Cooperative Highway Research Program (NCHRP) Report 350.

The manufacturer shall also certify that the material components of the completed blocks are resistant to the subterranean termites during its theoretical lifetime when tested in accordance with ASTM D3345. The theoretical lifetime is considered to be at least 20 years.

SECTION 222—MASONRY UNITS

222.01—Description

These specifications cover masonry units manufactured of regular or lightweight concrete or brick made from clay or shale in a plant specifically designed for such a purpose.

222.02—Detail Requirements

(a) **Wall Units:**

1. **Hollow load-bearing units** shall conform to the requirements of ASTM C90, Grade N-I.
2. **Hollow non-load bearing units** shall conform to the requirements of ASTM C129, Type I.
3. **Solid load-bearing units** shall conform to the requirements of ASTM C145, Grade N-I.
4. **Building bricks** shall conform to the requirements of AASHTO M114, Grade SW, or ASTM C55, Grade N-I.

(b) **Catch Basins and Manholes:**

1. **Masonry blocks** shall conform to the requirements of ASTM C139.
 2. **Bricks** shall conform to the requirements of AASHTO M91, Grade MS, or ASTM C55, Grade N-I.
- (c) **Sewer Brick:** Sewer brick shall conform to the requirements of AASHTO M91, Grade SM.

SECTION 223—STEEL REINFORCEMENT

223.01—Description

These specifications cover steel items designed to give added flexural strength to hydraulic cement concrete or to control and reduce cracking.

223.02—Detail Requirements

(a) **Reinforcement:**

1. **Deformed bars** shall conform to the requirements of ASTM A615, Grade 40 or 60.
2. **Plain bars** shall conform to the requirements of ASTM A615, Grade 40 or 60, deformation waived. When used as a dowel, material may be a plain bar conforming to the requirements of ASTM A615, Grade 40 or 60, or a plain dowel conforming to the requirements of ASTM A709, Grade 36.
3. **Welded wire fabric** shall conform to the requirements of ASTM A185. When used in continuously reinforced pavement, wire fabric shall be deformed and furnished in flat sheets and shall conform to the requirements of ASTM A497, high yield of 70,000 pounds per square inch.
4. **Longitudinal bars** for continuous reinforced concrete pavement shall conform to the requirements of ASTM A615, Grade 60.
5. **Structural steel** shall conform to the requirements of Section 226.
6. **Bar mats** shall conform to the requirements of ASTM A184.
7. **Spiral wire** shall conform to the requirements of AASHTO M32 or ASTM A82.
8. **Wire mesh** for use in gabions shall be made of galvanized steel wire at least 0.105 inch, 12 gage, in diameter. The tensile strength of the wire shall be at least 60,000 pounds per square inch. Wire mesh shall be galvanized in accordance with the requirements of ASTM A641, Class 3. When PVC coating is specified, it shall be at least 0.015 inch in thickness and shall be black.

Wire shall be welded to form rectangular openings or twisted to form hexagonal openings of uniform size. The linear dimension of the openings shall be not more than 4 1/2

inches. The area of the opening shall be not more than 9 square inches. The unit shall be nonraveling. *Nonraveling* is defined as the ability to resist pulling apart at any of the twists or connections forming the mesh when a single wire strand in a section is cut.

- (b) **Prestressing Tendons:** Seven-wire stress-relieved strands, stress-relieved wire, and low-relaxation strands shall conform to the requirements of ASTM A416, Grade 270; ASTM A421; and ASTM A416, Supplement I, respectively, with the following modifications:
1. Strands or wires used in units of any one-bed layout shall be manufactured by the same plant.
 2. A manufacturer's certification and load-elongation curve in accordance with the requirements of ASTM A416 or ASTM A421 shall be obtained by the prestressed concrete fabricator for each lot of strand. The data shall be submitted to the Engineer for approval in permanent record form.
- (c) **Reinforcing Steel to Be Epoxy Coated:** Steel shall conform to the requirements herein and shall be coated in accordance with the requirements of AASHTO M284.
1. Plants that epoxy coat reinforcing steel shall be CRSI certified for epoxy coating. CRSI inspection reports shall be on file at the plant and shall be available to the Engineer.
 2. Handling and storage of the coated bars shall conform to the requirements of AASHTO M284.
 3. Visible damage to the epoxy coating shall be patched or repaired with materials compatible with the existing coating in accordance with AASHTO M284.
- (d) **Reinforcing Steel to Be Galvanized:** Steel shall conform to the requirements herein and shall be galvanized in accordance with the requirements of ASTM A767.

SECTION 224—CASTINGS

224.01—Description

These specifications cover items cast from metal to a specific design in a manufacturing plant.

224.02—Materials

- (a) **Malleable castings** shall conform to the requirements of ASTM A47, Grade 32510.
- (b) **Gray iron castings** shall conform to the requirements of ASTM A48, Class 30S.
- (c) **Ductile iron castings** shall conform to the requirements of ASTM A536, Grade 60-40-18.
- (d) **Steel castings** shall conform to the following:

1. **Carbon steel** shall conform to the requirements of ASTM A27, Grade 65-35.
 2. **Chromium alloy steel** shall conform to the requirements of ASTM A296, Grade CA-15.
- (e) **Steel castings for bridges** shall conform to the requirements of ASTM A486, Class 70, or ASTM A27, Grade 70-36.

224.03—Detail Requirements

Tolerances, workmanship, and strength requirements for castings shall conform to the requirements of FS RR-F-621 Strength tests shall be performed in the presence of the Engineer. When the alternate load test is used, test bars shall be fully identifiable with regard to the casting lot.

SECTION 225—STEEL FORGINGS AND STEEL SHAFTING

225.01—Description

These specifications cover steel items specifically designed for a particular bridge structure and generally used where movement of a part of the structure is involved.

225.02—Detail Requirements

- (a) **Steel forgings** shall conform to the requirements of ASTM A668, Class D, for use with structural carbon steel and Class F for use with high-strength low-alloy steel.
- (b) **Steel shafting** shall conform to the requirements of ASTM A108, Grades 1016 through 1030.

SECTION 226—STRUCTURAL STEEL

226.01—Description

These specifications cover steel structural shapes furnished to specific dimensions and associated hardware and fasteners.

226.02—Detail Requirements

- (a) **Bridge Structural Steel:** Structural steel for bridge shall conform to the requirements of ASTM A709 for the grade specified except that stud shear connectors shall conform to the requirements of (e) herein. Steel for tensile flanges and webs of plate girders, rolled beams, cover and splice plates, and any other components designated as main load-carrying compo-

nents subject to tensile stress shall conform to the supplemental requirements of ASTM A709 for the Charpy V-Notch tests for Zone Two.

Fracture-critical bridge steel members designated on the plans shall conform to the requirements of the AASHTO Guide Specifications for Fracture Critical Non-Redundant Steel Bridge Members.

One copy of the mill analysis for bridge steel shall be submitted to the Engineer.

- (b) **Other Structural Steel:** Unless otherwise specified, steel for other structural members including H-piles shall conform to the requirements of ASTM A709, Grade 36. One copy of the mill analysis shall accompany steel piles shipped to the project site. Three copies of the mill analysis for structural steel members shall be submitted to the Engineer.
- (c) **Anchor Bolts:**
1. Anchor bolts for general use shall conform to the requirements of AASHTO M314, Grade 36. Nuts shall conform to the requirements of ASTM A563, and washers shall conform to the requirements of ASTM F844. Threads shall be coarse series.
 2. High-strength anchor bolts shall conform to the requirements of AASHTO M314, Grade 55, with supplemental requirements of S1. Nuts and washers shall conform to the requirements of (h) herein.
 3. Galvanization of steel anchor bolts, nuts, and washers shall conform to the requirements of ASTM A153.
 4. Anchor bolts for railings shall conform to the requirements of (c)1. herein and shall be hot-dipped galvanized
- (d) **Stud Shear Connectors:** These shall conform to the requirements of AWS D1.1 Structural Welding Code or AWS D1.5 Bridge Welding Code as applicable. Stud shear connectors that conform to these requirements and are on the Department's approved list may be used without further testing.
- (e) **Steel for Structural Supports for Light Poles and Traffic Control Devices:** Steel shall be suitable for the design requirements and shall conform to the following:

Characteristic	Value
Min. yield strength	36,000 psi
Min. tensile strength	58,000 psi
Min. elongation (in 8 inches)	18%
Min. elongation (in 2 inches)	20%
Carbon equivalent (as determined by AWS D1.1/D1.5)	Max. 0.45%

Charpy V-notch values of 25 foot pounds at 10 degrees F may be substituted for elongation requirements. Tubing conforming to the requirements of ASTM A500 shall have Charpy V-notch values of 25 foot pounds at 10 degrees F.

Steel conforming to the requirements of ASTM A709, Grade 50W, shall not be used unless specified.

- (f) **Steel for Timber Connectors:** Steel shall conform to the requirements of ASTM A711 or AISI No. 1015.
- (g) **Bolts, Nuts, and Washers:** Bolts shall conform to the requirements of ASTM A307 except where high-strength or other special types of bolts are required. Nuts for bolts conforming to the requirements of A307 shall conform to the requirements of ASTM A563, and washers shall conform to the requirements of ASTM F844. Lock washers shall conform to the requirements of ANSI B18.21.1.
- (h) **High-Strength Bolts, Nuts, Washers, and Direct Tension Indicators:** These items shall conform to the requirements of the following ASTM specifications:

High-Strength Bolts	Nuts for Use with High-Strength Bolts, Heavy Hex	Washers (Hardened)	Direct Tension Indicators
ASTM A325, Type 1	ASTM A563, Grade DH ASTM A194, Grade 2H	ASTM F436	ASTM F959
ASTM A325, Type 3	ASTM A563, Grade DH3	ASTM F436	ASTM F959
ASTM A325, Galvanized	ASTM A563, Grade DH	ASTM F436	ASTM F959
ASTM A490, Types 1 or 2	ASTM A563, Grade DH ASTM A194, Grade 2H	ASTM F436	ASTM F9599
ASTM A490, Type 3	ASTM A563, Grade DH3	ASTM F436	ASTM F959

1. Bolts, nuts, and washers conforming to the requirements of ASTM A490 shall be plain (uncoated), and bolts, nuts, and washers conforming to the requirements of ASTM A325, Type 1, shall be galvanized. High-strength bolts used with unpainted weathering steel shall conform to the requirements of ASTM A325, Type 3, or, when specified, ASTM A490, Type 3.
2. The maximum hardness for bolts conforming to the requirements of ASTM A325 shall be 33R. The maximum tensile strength for such bolts shall be 150 kips per square inch for bolts 1 inch or less in diameter and 120 kips per square inch for larger bolts.
3. High-strength fasteners (plain and coated) shall be subjected to a rotational-capacity test similar to the supplementary requirements of ASTM A325 and ASTM A490 and as modified by the following:
 - a. Washers shall be used in the rotational-capacity test even though they may not be specified for use. Each combination of a bolt production lot, a nut production lot, and a washer production lot shall be tested as an assembly. A rotational-capacity lot number shall be assigned to each combination of lots tested. When washers are not specified for use, they need not be included in the rotational-capacity lot number. The minimum frequency of testing shall be two assemblies per shipping lot.

Starting with 10 percent of the specified proof load using a Skidmore-Wilhelm calibrator or equivalent tension-measuring device, the assembly shall withstand the number of turns indicated without breaking:

- (1) Bolt length up to and including 4 diameters: 2/3 turn
- (2) Bolt length over 4 but not exceeding 8 diameters: 1 turn
- (3) Bolt length over 8 but not exceeding 12 diameters: 1 1/3 turn

Bolts too short to test in a Skidmore-Whilhelm Calibrator shall be tested using steel plate(s) without the specified proof load requirement.

- b. During this test, the minimum recorded tension shall be at least 1.15 times the required bolt proof load as specified in ASTM A325 and ASTM A490:

1.15 x Proof Load (lb)

Bolt Size (in)	ASTM A325	ASTM A490
1/2	13,800	19,600
5/8	22,000	31,100
3/4	32,600	46,100
7/8	45,100	63,700
1	59,200	83,600
1 1/8	64,900	105,200
1 1/4	82,400	133,700
1 3/8	98,200	159,300
1 1/2	119,600	193,800

- c. The measured torque to produce the required fastener tension shall not exceed the value obtained by the following equation:

$$\text{Torque} = 0.25 PD$$

Where:

Torque = measured torque (foot-pounds)

P = measured bolt tension (pounds)

D = nominal diameter (feet).

Max. Torque 1.15 x Proof Load (ft-lb)

Bolt Size (in)	ASTM A325	ASTM 490
1/2	140	200
5/8	280	400
3/4	500	720
7/8	820	1,160
1	1,230	1,730
1 1/8	1,510	2,460
1 1/4	2,140	3,470
1 3/8	2,800	4,550
1 1/2	3,730	6,040

- d. Bolts shall be proof-load tested in accordance with the requirements of ASTM F606, Method I. Full-size bolts shall be wedge tested in accordance with the requirements of ASTM F606. Nuts shall be proof-load tested in accordance with the requirements of ASTM F606. Galvanized bolts shall be wedge tested after galvanizing. Galvanized nuts shall be proof-load tested in accordance with the requirements of ASTM F606 only when overtapping, galvanizing, and lubricating operations are completed.
- e. Galvanized bolts, nuts and washers shall be hot-dipped galvanized by the hot-dipped method in accordance with the requirements of ASTM A153. If the bolts are to be topcoated with paint, mechanically galvanized bolts, nuts, and washers that conform to the requirements of ASTM B695, Class 50, may be used.

When galvanized nuts conforming to the requirements of ASTM A563 are specified, the amount of over tapping may be less than specified; however, all nuts in each lot shall be over tapped the same amount. Galvanized nuts shall be lubricated in accordance with the requirements of ASTM A563 using a lubricant sufficiently tinted so as to be readily visible.

Galvanized bolts, nuts, and washers shall have the galvanization measured for thickness. Measurements for bolts shall be taken on the wrench flats or top of the bolt head. Measurements for nuts shall be taken on the wrench flats.

When galvanized washers are specified, hardness testing shall be performed after galvanizing. The coating shall be removed prior to testing.

- f. Bolts, nuts, and washers shall be identified with a marking that identifies their manufacturer. The Contractor shall provide an example of such marking and the certification of each manufacturer for the bolts, nuts, and washers supplied. The Contractor shall also provide written documentation of all tests required by ASTM and by specifications herein for bolts, nuts, and washers. Documentation shall indicate the results of such tests, the address where the tests were performed and the date of testing. Test results of bolts and nuts shall also indicate the lot number of the product. Bolts, nuts, and washers from different rotational-capacity lots shall not be shipped in the same container. In addition, shipping containers shall be marked with the rotational-capacity test lot number of the product supplied.

SECTION 227—STEEL GRID FLOORING

227.01—Description

These specifications cover plant-fabricated steel for use as a portion of a bridge deck.

227.02—Materials

- (a) **Steel** shall conform to the requirements of ASTM A709, Grade 36, except that material which is not galvanized shall have a copper content of at least 0.2 percent.
- (b) **Concrete** for filling steel grid floors shall conform to the requirements of Section 217 for Class A3, maximum aggregate size No. 7.

227.03—Detail Requirements

- (a) **Open flooring** shall be galvanized in accordance with the requirements of ASTM A123.
- (b) **Painting**, when specified or permitted, shall be performed in accordance with the requirements of Section 411 except that dipping will be permitted.

SECTION 228—STEEL PILES

228.01—Description

These specifications cover steel fabricated to a shape that will act as a foundation for a structure. One copy of each applicable mill analysis shall accompany steel piles shipped to the project, and four copies shall be submitted to the Engineer.

228.02—Detail Requirements

- (a) **H-piles:** H-piles shall be structural carbon steel conforming to the requirements of ASTM A709, Grade 36.
- (b) **Shell Piles:** Welded shells shall be fabricated with butt welds only.

End plates and other fittings shall be fabricated from the same material used for the shell or from steel conforming to the requirements of ASTM A709, Grade 36.

1. **Steel for Type A shells** shall be classification SAE 1010 with a yield point of at least 50,000 pounds per square inch. Shells shall be fluted and consist of a cylindrical upper section(s) and a lower section having a diameter diminishing at the rate of at least 1/8 but not more than 1/4 inch per foot. The lower section shall have a welded point with a diameter of at least 8 inches.
2. **Steel for Type B shells** shall conform to the requirements of ASTM A252, Grade 1, 2, or 3. Shells shall be straight pipe having bottoms closed with end plates at least 3/4 inch in thickness and a diameter not more than 1/2 inch greater than the outside diameter of the shell.
3. **Steel for Type C shells** shall conform to the requirements of ASTM A569 or A366. Shells shall be helically corrugated and cylindrical in the section and shall diminish in

diameter toward the point by stepping at regular intervals at the rate of approximately 1 inch per step or at an average rate of at least 1/8 but not more than 1/4 inch per foot. The lower section shall have a welded point with a diameter of at least 8 inches.

4. **Steel for Type D shells** shall be classification SAE 1010 with a yield point of at least 50,000 pounds per square inch. Shells shall be helically corrugated and of a constant cylindrical section or shall diminish uniformly in diameter at the rate of at least 1/8 but not more than 1/4 inch per foot. Bottoms shall have ends closed with plates at least 3/4 inch in thickness and not more than 1/2 inch greater in diameter than the outside diameter of the shell. Shells diminishing in diameter shall have welded points with a diameter of at least 8 inches.
- (c) **Steel Sheet Piles:** Steel sheet piles shall conform to the requirements of ASTM A328.

SECTION 229—ALUMINUM ALLOY

229.01—Description

These specifications cover aluminum alloy products designed in shape and composition to serve a specific purpose, such as a sign panel, post, or conduit, including necessary fasteners.

229.02—Detail Requirements

- (a) **Sheets and plates** shall conform to the requirements of ASTM B209, alloy 6061-T6, 6061-T651, 5052-H32, 5052-H34, 3003-H14, or 5086-H116/H32. Aluminum sign panels shall be alloy 5052-H32, 5052-H34, 5052-H38, or 6061-T6.
- (b) **Bars, rods, and wire** shall conform to the requirements of ASTM B211, alloy 6061-T6 or 6061-T651.
- (c) **Extruded bars, rods, shapes, and tubes** shall conform to the requirements of ASTM-B221, alloy 6061-T6 or 6063-T6.

Aluminum alloy extrusions, extruded tubes, drawn tubes, or pipes that are to be bent on a radius of less than 3 feet may be made from alloy having a temper condition of 0.

- (d) **Drawn tubes** shall conform to the requirements of ASTM B210, alloy 6061-T6.
- (e) **Pipe** shall conform to the requirements of ASTM B429 or ASTM B241, alloy 6061-T6 or 6063-T6.
- (f) **Bolts, studs, nuts, set screws, washers, and rivets** shall be furnished as commercial items suitable for the application.
- (g) **Permanent-mold castings** for items other than rail posts shall conform to the requirements of ASTM B108, alloy 356.0-T6. Cast aluminum alloy rail post shall conform to the requirements of ASTM B108, alloy A444.0.

- (h) **Sand castings** shall conform to the requirements of ASTM B26, alloys 319-F, 319.0-T6, 356.0-F, 356.0-T6, or 535.0-F.
- (i) **Shims** shall be made from a sheet or plate conforming to the requirements of ASTM B209, alloy 1100-O.
- (j) **Aluminum filler metal for welding** shall conform to the requirements of AWS 1.2.
- (k) **Rolled or extruded structural shapes** shall conform to the requirements of ASTM B308, alloy 6061-T6.
- (l) **Breakaway support couplings for light poles and sign posts** shall conform to the requirements of ASTM B209 or ASTM B221, alloy 6061-T6.
- (m) **Frangible bases for light and signal poles** shall conform to the requirements of ASTM B26 or ASTM B108, alloy 319 or 356.0-T6.
- (n) **Aluminum alloy for controller, control center, and flasher cabinets** shall conform to the requirements of ASTM B209, alloy 5052-H32.
- (o) **Aluminum alloy for lighting and pedestal poles** shall conform to the requirements of ASTM B221, ASTM B241, or B429, alloy 6063-T6.

SECTION 230—BRONZE AND COPPER ALLOY

230.01—Description

These specifications cover the fabrication of specific bronze or copper alloys, usually in the construction of a bridge structure or for electrical purposes.

230.02—Detail Requirements

- (a) **Cast bronze** shall conform to the requirements of ASTM B22.
- (b) **Copper alloy** shall conform to the requirements of ASTM B100, copper alloy No. 51000.
- (c) **Copper sheets and strips** shall conform to the requirements of ASTM B370.

SECTION 231—PAINT

231.01—Description

These specifications cover a mixture of pigment in a liquid vehicle that, when applied, will dry to an opaque solid film. Use of paint in these specifications refers to the requirements of highway construction. Paint materials not specified herein shall be as specified by the manufacturer.

231.02—Materials

The paint shall not be formulated with any compounds of the heavy metals listed in 40 CFR 261.24, Table 1, except that barium sulfate is allowed. Except for barium sulfate, total heavy metal levels shall not exceed 20 times the specified regulatory limits. Volatile organic compound (VOC) content shall not exceed 2.8 pounds per gallon as applied, except zinc rich primers shall not exceed 3.5 pounds per gallon as applied.

When Federal Standard (FS) color numbers are specified, they refer to color only and not to gloss requirements.

- (a) **Paint vehicles** shall conform to the following requirements:

Vehicle	Specification
Acrylic resin	100% straight acrylic polymer dispersed in water
Alkyd resin	FS TT-R-266, Type I, Class A or B
Linseed oil	
Boiled	ASTM D260, Type I
Heat bodied	FS TT-L-201
Raw	ASTM D234
Methyl ethyl ketone	ASTM D740
Mineral spirits	ASTM D235
Soybean oil	
Refined	ASTM D1462
Degummed	ASTM D124
Spar varnish	FS TT-V-121
Toluene	ASTM D841
Tricresyl-phosphate	ASTM D363
Volatile thinners	ASTM D235
2-ethoxyethanol acetate	ASTM D3728

- (b) **Paint pigments** shall conform to the following requirements:

Pigment	Specification
Aluminum paste	ASTM D962
Carbon black	ASTM D561, Type I
Lamp black	ASTM D209
Magnesium silicate	ASTM D605
Micaceous iron oxide	Processed specular hematite ore with lamellar structure that conforms to the requirements of ASTM D 5532, Type I
Organo montmorillonite	Fine, creamy white powder with high gelling efficiency in a wide range of organic liquids; water content less than 30% and fineness less than 5% retained on No. 200 (75 µm) sieve
Raw Sienna	ASTM D765
Titanium dioxide	ASTM D476, Rutile
Yellow iron oxide	ASTM D768
Zinc dust	ASTM D520, Type II
Zinc oxide	ASTM D79

231.03—Detail Requirements

Paints shall not settle excessively or cake in the container; shall be readily broken up with a paddle or power mixer to a smooth uniform paint of acceptable consistency and working properties with a minimum of foaming; shall not thicken, liver, skim, or curdle; and shall retain these properties in storage for at least 12 months.

When applied in accordance with the standard practice, paint shall show good leveling properties; be free from laps, brush marks, orange peel, sags, or other surface defects; and shall flow out to a uniform, smooth finish.

Paints will be inspected, sampled, and tested in accordance with the requirements of Federal Test Method Standard No. 141.

Paint containers shall be plainly marked with the name of the material, date of manufacture, lot number and/or batch number, Department color, quantity contained therein, and name and address of the manufacturer. A manufacturer's product data sheet shall also be provided. Any package or container not provided as specified will be rejected.

- (a) **Zinc-rich paint systems** (System B) shall consist of a zinc-rich primer; an intermediate coat when recommended by the manufacturer; and a topcoat, which shall be selected from the Department's approved products list. Zinc-acrylic-acrylic systems shall be tested in accordance with the requirements of VTM-73. Zinc-rich-epoxy-urethane paint systems approved by the Northeast Protective Coating Committee (NEPCOAT) or those systems tested in accordance with the requirements of AASHTO R-31 will be evaluated for inclusion to the Qualified Low Volatile Organic Compound Zinc Rich Paint Systems List .

Primer for shop application shall be inorganic zinc and shall conform to the slip coefficient requirements of AASHTO 1995 Interim Provision, Division I, Design, Table 10.32.3C, Class B.

- (b) **No. 14 paint, aluminum epoxy mastic**, (System F) shall be a two-component, modified epoxy coating, aluminum in color.

1. **Composition:** Pigment shall be flake metallic aluminum and shall contain rust-inhibiting and inert pigments.

The paint vehicle shall be a modified epoxy resin and curing agent and shall not contain coal tar. Paint shall be supplied as a two-package material with a 1:1 mixture ratio by volume.

2. **Physical Requirements:** The epoxy mastic shall contain at least 90 percent solids by weight when tested in accordance with the requirements of ASTM D1644, modified to a drying time of 72 hours at 100 degrees F.

The shelf life of epoxy mastic components shall be at least 6 months. There shall be no skinning, gelling, or hard settling that does not disperse.

The viscosity of mixed paints measured immediately after the blending and mixing of components shall be from 80 to 140 Kneb units at 77 ± 2 degrees F.

The weight per gallon of mixed paint shall be at least 10.8 pounds at 77 ± 2 degrees F.

The appearance of the dry applied film shall be bright aluminum.

The epoxy mastic shall be suitable for use over properly prepared, inorganic zinc-rich primers. A mist coat may be required to minimize bubbling.

Mixed paint, when thinned in accordance with the manufacturer's recommendations for application over wire-brushed rusty steel, shall be capable of being spray applied in one coat at a wet film thickness of 10 mils without runs or sags.

The epoxy mastic, when applied in a dry film thickness of 5 mils and air dried at 75 degrees F, shall be dry to the touch within 24 hours; dry enough to handle in 48 hours; and provide a hard tough film after 5 days.

The usable pot life of the mixture of components reduced as recommended shall be at least 3 hours at 70 degrees F and 1 1/2 hours at 90 degrees F.

The epoxy-mastic coating shall possess such flexibility that when applied in a dry film thickness of 5 mils to a 1/8-inch steel panel that has been blast cleaned in accordance with the requirements of SSPC-5 and cured for 2 weeks at 75 degrees F, it shall not display signs of cracking or loss of adhesion when the panel is uniformly bent 180 degrees around a mandrel 8 inches in diameter.

3. **Resistance:** Steel test panels conforming to the requirements of ASTM D609 shall be abrasive blasted in accordance with the requirements of SSPC-SP 5, exposed to the atmosphere for 30 days so that a uniform rusting occurs, and then hand cleaned with a wire brush in accordance with the requirements of SSPC-SP 2. The panel shall then be spray applied with epoxy mastic to achieve a dry film thickness of 5 mils and cured in accordance with the manufacturer's recommendations.
 - a. **Fresh Water:** Coated panels shall be scribed down to base metal with an X having at least 2-inch legs and immersed in fresh tap water at 75 ± 5 degrees F. Upon examination after 30 days of immersion, panels shall be unaffected except for dis-

coloration of the epoxy-mastic coating. There shall be no blistering, softening, or visible rusting of the coating beyond 1/16 inch from the edge of the scribe mark.

- b. **Salt Water:** Panels shall be scribed down to the base metal with an X having at least 2-inch legs and immersed in a 5 percent sodium chloride solution at 75 ± 5 degrees F. Panels shall be unaffected, except for discoloration of the epoxy-mastic coating, upon inspection after 7, 14, and 30 days of immersion. There shall be no blistering, softening, or visible rusting of the coating beyond 1/16 inch from the center of the scribe mark. The sodium chloride solution shall be replenished with fresh solution after each examination.
 - c. **Weathering:** Panels shall be tested in accordance with the requirements of ASTM G23, Type D, at the beginning of the wet cycle. After 1,000 hours of continuous exposure, the coating shall show no rusting, loss of adhesion to the steel test panel, or blistering.
 - d. **Salt Fog:** Panels shall be scribed with an X having at least 2-inch legs down to base metal. Test panels shall then be tested in accordance with the requirements of ASTM B117. After 1,000 hours of continuous exposure, the coating shall show no rusting or blistering beyond 1/16 inch from the center of the scribe mark or a loss of bond.
4. **Packaging and Labeling:** Epoxy-mastic coating shall be packaged in two containers labeled "Part A" and "Part B." Each container shall bear a label that clearly shows the manufacturer and brand name of the paint, lot number, and date of manufacture. The label on the vehicle container shall also include complete instructions for use. The container shall be coated, if necessary, to prevent attack by the paint components.
 5. **Application:** The manufacturer's current printed instructions for applying aluminum epoxy-mastic coating shall be submitted to the Department for approval prior to application.
 6. **Product Certification:** The manufacturer shall certify that the modified aluminum epoxy mastic has been used successfully for at least 2 years in a similar service and environment and that the material was applied in one coat at a dry film thickness of 5 mils. Successful performance shall include adhesion to steel and old coatings of the type found on bridges.

Prior to approval and use of an aluminum epoxy-mastic coat, the manufacturer shall submit a certified test report from an independent testing laboratory showing specific test results conforming to all quantitative and resistance test requirements herein. The test report shall also contain the lot numbers from which the data were compiled, manufacturer's name, and brand name of the paint. Upon approval by the Department, the product will be placed on the Department's Qualified No. 14 Aluminum Epoxy Mastic Coatings List (System F) and further resistance and quantitative tests will not be required of that manufacturer for that brand name of paint unless random samples tested by the Department show nonconformance with any of the requirements herein. The manufacturer shall submit new certified test results when the manufacturing process or paint formulation is changed.

- (c) **Colored epoxy mastic** for use as a finish coat over No. 14 primer (System F) shall be supplied by the manufacturer of the primer and shall conform to the salt fog resistance requirements specified in (b) herein. Upon approval by the Department, the colored epoxy mastic will be placed on the Qualified No. 14, Aluminum Epoxy Mastic Coatings List (System F) as an approved colored topcoat.
- (d) **Colored urethane topcoats** for use as a finish coat over No. 14 primer (System F) shall be an aliphatic urethane from the Department's Qualified No. 14, Aluminum Epoxy Mastic Coatings List (System F) as an approved colored topcoat.
- (e) **No. 101, 102, and 103 water reducible paint** (System W) shall be a one-component acrylic water borne paint with a VOC of less than 2.8 pounds per gallon as applied.

1. **Composition:**

	No. 101		No. 102		No. 103	
	Min.	Max.	Min.	Max.	Min.	Max.
Pigment (% by weight)	20	25	35	40	10	20
Red iron oxide (86% Fe ₂ O ₃)	45					
Zinc phosphate	10		5		5	
Phthalocyanine Blue		2				
Calcium carbonate			30			
Titanium dioxide (ASTM D476, Type II)			45			
Magnesium silicate				12		
Tinting compounds ¹						95
Vehicle (% by weight)	75	80	60	65	80	90
HG-54 solids	30		30		30	
Water		55		55		58
Methyl carbitol	5		5		5	
Texanol	2		2		5	
Dibutyl phthalate	2		2			
Paint Characteristics						
Weight per gallon (pound)	9.7		11.0		9.0	
Solids by volume	35		37		30	
Grind	5		5		5	
Viscosity (KU)	90	100	90	100	90	100
Drying time (ASTM D1640)						
Set to touch (hr)		3		3		3
Drying time (hr)		24		24		24
Leneta sag	10		10		10	
pH	8.0	8.5	8.0	8.5	8.0	8.5
Adhesion (ASTM 3359)	3B		3B		3B	
Gloss, specular at 80 degrees					40	

¹Tinting compounds shall be prime-hiding pigments.

2. **Mixed Paint:** Mixed paint shall not liver, thicken, curdle, or gel or settle rapidly. After mixing, all coarse particles and skins shall not amount to more than 0.05 percent by weight of the total mixture when passed through a 60-mesh screen.

3. **Storage Life:** The paint shall not show thickening, curdling, gelling, or gassing after being stored for 1 year from date of manufacture when packaged in tightly covered unopened containers at a temperature between 50 degrees and 90 degrees F.
4. **Working Properties:** The paint shall spray easily and show no streaking, running, or sagging when tested in accordance with Federal Test Method Standard 411, Methods 4331 and 4541.

SECTION 232—PIPE AND PIPE ARCHES

232.01—Description

These specifications cover materials used for the conveyance of water, including drainage, storm water, sanitary systems, and waste water.

232.02—Detail Requirements

The Contractor shall obtain and provide from his supplier a quality control plan acceptable to the Department for determination of conformance with the applicable requirements in the production of concrete and corrugated metal culvert and underdrain pipe.

(a) Concrete Pipe:

1. **Concrete pipe for culverts and sewers** shall be circular or elliptical in cross-section, either plain concrete or reinforced concrete, and of the modified tongue-and-groove design in sizes up to and including 18 inches in internal diameter and either standard or modified reinforced tongue-and-groove in sizes above 18 inches in internal diameter. Pipe shall conform to the specified AASHTO requirements except that pipe having an internal diameter of 36 inches or less shall be manufactured without lift holes. Pipe larger than 36 inches in internal diameter may be manufactured with lift holes provided the holes are created by molding, forming, coring, or other methods to be cylindrical or conical in shape and are sufficiently smooth to permit plugging with an elastomeric or other approved plug type.
 - a. **Plain concrete culvert pipe** shall be composed of hydraulic cement, water, and mineral aggregates conforming to the requirements of b(3) and b(4) herein. Pipe shall conform to the following:

Min. Inside Diameter (in)	Min. Wall Thickness (in)	Groove Depth (in)	Crushing Strength (lb/lin ft)
12	1 3/4	1 3/4	1,800
15	2	1 3/4	2,125
18	2	1 3/4	2,400
21	2 3/4	2	2,700
24	3	2 1/4	3,000

Pipe shall also comply with the requirements of AASHTO M170 for manufacture, finish, marking, inspection, and rejection.

b. **Reinforced concrete culvert pipe:**

- (1) **Circular pipe** shall conform to the requirements of AASHTO M170, class as specified, or AASHTO M242. Circular pipe that does not have values listed in the AASHTO M170 design tables for diameter, wall thickness, compressive strength, and reinforcement shall be certified in accordance with the requirements of Section 105.10. Pipe conforming to the requirements of AASHTO M242 shall also be certified in accordance with the requirements of Section 105.10.
 - (2) **Elliptical pipe** shall conform to the requirements of AASHTO M207, class as specified. Elliptical pipe that does not have values listed in the AASHTO M207 design tables for wall thickness, compressive strength, and reinforcement shall be certified in accordance with the requirements of Section 105.10.
 - (3) **Fine aggregate** shall conform to the requirements of Section 202 for quality except that the void content, grading, and uniformity shall be controlled as necessary to produce the specified level of strength and absorption.
 - (4) **Coarse aggregate** shall conform to the requirements of Section 203 for Grade A crushed stone or gravel.
 - (5) **Positioning of reinforcement** when two layers of wire or bar reinforcement are used shall be such that welded joints are at an angle of approximately 60 degrees to each other.
 - (6) **Strength tests** will be performed by the three-edge bearing method in accordance with the requirements of AASHTO T280 or by the testing of cores in accordance with the requirements of ASTM C42. Hand-cast pipe and end sections may be tested in accordance with the requirements of ASTM C39 and C31.
 - (7) **Absorption tests** will be performed in accordance with the requirements of AASHTO T280 on specimens of broken pipe or cores.
2. **Concrete pipe for underdrains** shall conform to the requirements of AASHTO M86, Class I, and the perforation requirements of AASHTO M175, Type I, except that spalls shall be not more than 1 1/2 inches in diameter or 3/16 inch in depth and shall not adjoin. When used as combination underdrains, pipe shall not be perforated.

Porous concrete pipe for underdrains shall conform to the requirements of AASHTO M176, standard strength.

3. **Concrete pipe for water lines, water mains, and sanitary sewers:**

- a. **Concrete pressure pipe** (steel cylinder) shall conform to the requirements of AWWA C300, AWWA C301, or AWWA C303 for the size, minimum working pressure, protective coating, seal coat, and type of joint as specified.
- b. **Nonreinforced concrete sanitary sewer pipe** shall conform to the requirements of AASHTO M86 for the class specified.
- c. **Reinforced concrete water pipe** (nonylinder) shall conform to the requirements of AWWA C302 for size, minimum working pressure, seal coat, protective coating, and type of joint specified.
- d. **Reinforced concrete sanitary sewer pipe** shall conform to the requirements of AASHTO M170 for the class specified.

(b) **Cast Iron and Ductile Iron Pipe and Fittings:**

1. **Cast iron pipe** shall conform to the requirements of ASTM A888 for the class specified.
2. **Ductile iron pipe** shall conform to the requirements of AWWA C151 for size, joint type, class, type of coating and lining as specified, and minimum working pressure if applicable. Flanged joints shall conform to the requirements of AWWA C115.
3. **Fittings** for cast iron and ductile iron pipe for water lines, water mains, and sanitary sewers shall conform to the requirements of AWWA C110 (ANSI A21.10) or AWWA C153 (ANSI A21.53) for size, joint type, pressure rating, and type of coating and lining as specified.
4. **Cement mortar linings** shall conform to the requirements of AWWA C104 (ANSI A21.4).

(c) **Steel Pipe:**

1. **Corrugated steel culvert pipe and pipe arches** shall conform to the requirements of AASHTO M36 except that helically formed pipe shall be tested in accordance with the requirements of AASHTO T249 at the rate of one test per week per corrugation machine per work shift. Records of such test shall be maintained for a period of 24 months. Pipe shall be fabricated from materials conforming to AASHTO M218 for galvanized pipe, AASHTO M274 for aluminum coated pipe, AASHTO M246 for polymer coated pipe and AASHTO M289 for aluminum zinc alloy coated pipe. Steel spiral rib pipe shall be of smooth wall spiral rib construction. When connecting bands or flared end sections are required, helically formed pipe shall have rerolled ends with a minimum of two annular corrugations. End sections shall be produced in accordance with the general requirements of AASHTO M36 from materials conforming to the applicable requirements of AASHTO M218 for use with galvanized pipe, AASHTO M274 for use with aluminum-coated or polymer coated pipe, or AASHTO M289 for use with aluminum zinc alloy-coated pipe.

Pipe sections shall be joined with annular corrugated bands, hugger bands, or maxidimple bands conforming to the requirements of AASHTO M36 and shall be designed to form a leak-resistant joint. Maxidimple bands shall have two rows of circumferential dimples spaced approximately 4 to 6 inches on center. Coupling band widths shall be at least 7 inches for pipe 12 through 30 inches in diameter and 10 1/2 inches for pipe 36 through 120 inches in diameter. Coupling bands shall be not more than 0.109 inch (12 gage) and not less than 0.052 inch (18 gage) in thickness, and the thickness shall be equal to the pipe thickness or up to two numerical thicknesses lighter than the pipe thickness. (*Example:* For 12-gage pipe, coupling bands may be 12, 14, or 16 gage.) Coupling bands shall have the same metallic or polymer coating as the pipe sections on which they are connecting.

2. **Asphalt-coated corrugated steel culvert pipe and pipe arches** shall conform to the requirements of AASHTO M190 with the following modifications:

- a. Steel to be coated shall be free from contaminants and shall be immersed in asphalt having a temperature of 400 ± 5 degrees F. When pipe is preheated to 300 degrees F, the temperature of the asphalt shall be at least 375 degrees F.

The duration of the first immersion of the steel in the hot asphalt shall be at least as follows:

Pipe Thickness (in)	Time (min)
0.052	2
0.064	2.5
0.079	3
0.109	5
0.138	6.5
0.168	8

- b. Steel shall be dipped a second time to give a total coating of at least 0.050 inch in thickness.
- c. Coupling bands need not be coated unless required for watertightness.
- d. Samples for testing asphalt may be taken from the dipping vat prior to coating.
- e. When a sheet with a thickness other than the minimum specified for a particular size of pipe or arch is to be coated, an embossed seal bearing the thickness of the steel shall be attached to each pipe or arch prior to dipping the pipe or arch in asphalt. The seal shall be secured through a drilled or punched hole, having a diameter of not more than 3/8 inch, approximately 1 inch from the end of the section of the pipe or arch. The seal shall remain attached to the pipe or arch for rapid identification of the thickness of the steel.
- f. A mastic may be used in lieu of applying asphalt coating in the shop. Mastic shall conform to the requirements of and be applied in accordance with the requirements of AASHTO M243.

3. **Corrugated steel pipe for underdrains** shall conform to the requirements of AASHTO M36.
4. **Black and galvanized steel pipe:**
 - a. **Black steel pipe for bridge deck drains and drainage systems** shall conform to the requirements of ASTM A53, extra strong (Schedule 80), with a wall thickness of at least 0.337 inch except that the hydrostatic test will not be required.
 - b. **Galvanized steel pipe for handrails** shall conform to the requirements of ASTM A120 or ASTM A53 for standard or extra strong pipe as indicated except that the hydrostatic test will not be required.
 - c. **Black and galvanized steel pipe for miscellaneous items** shall conform to the requirements of ASTM A53 except that the hydrostatic test will be required only when the pipe is used as pressure pipe.
5. **Smooth wall pipe (jacked or casing for general use):**
 - a. **Steel encasement pipe** shall conform to the requirements of ASTM A139 with a minimum wall thickness of 0.500 inch or ASTM A53 Standard Weight Class and shall have beveled edges suitable for welding or be threaded. The hydrostatic test for such pipe will be waived.
 - b. **Pipe for jacking** shall be of sufficient strength, diameter and wall thickness to accomplish the specific task and shall be approved by the Engineer.
6. **Steel water pipe, flanges, and fittings:**
 - a. **Steel pipe** shall conform to the requirements of AWWA C200 for the minimum design working pressure, wall thickness, and type of pipe ends as specified. The protective coating shall conform to the requirements of AWWA C203 for coal tar protective coating, and the lining shall conform to the requirements of AWWA C205 for cement mortar lining.
 - b. **Flanges** shall conform to the requirements of AWWA C207 as specified for pressure rating and size.
 - c. **Fittings** shall conform to the requirements of AWWA C208.
7. **Galvanized steel water pipe and fittings:**
 - a. **Galvanized steel pipe** shall conform to the requirements of ASTM A53, Schedule 40 or 80, for the size; method of manufacture; type, plain or threaded; couplings; and class specified.
 - b. **Fittings** shall be galvanized malleable iron conforming to the requirements of ASTM A47. Threads shall conform to the requirements of ANSI B2.1.
8. **Concrete-lined corrugated steel pipe** shall conform to the requirements of Section 232.02(c)1. and shall be fabricated from material conforming to AASHTO M274 for

aluminum coated pipe. The concrete lining shall be at least 1/8 inch in thickness over the inside crest of corrugation. Concrete for the lining shall be composed of cement, sand, and water, mixed to produce a dense, homogeneous lining.

Pipe sections shall be connected using a hugger band with O-rings. After pipe is installed, the separation between pipe sections shall be filled with a cement grout. After finishing, the area shall be sprayed with a liquid membrane-forming compound.

9. **Polymer coated steel pipe** shall conform to the requirements of Section (c)1 herein. Polymer coating material shall conform to AASHTO M246 and be composed of polyethylene and acrylic acid copolymer. Polymer coating shall have a minimum thickness of 0.01 inch and shall be applied to both sides of the pipe material. Polymer coating shall be labeled with the brand name of the material and the manufacture in accordance with AASHTO M246.
 10. **Corrugated steel double wall pipe** shall conform to the requirements of Section (c)1 herein. Corrugated steel double wall pipe shall consist of a standard corrugated steel exterior shell that meets the structural requirements for the pipe and a smooth interior steel liner. The interior liner is to be continuously attached to the exterior shell along the lock seam. The interior liner is to have a minimum thickness of 0.052 inches. Both the exterior shell and the interior liner are to have a polymer coating applied to both sides of the pipe material in accordance with Section (c)9, herein.
- (d) **Structural Plate Pipe, Pipe Arches, and Arches:** Pipe, pipe arches, and arches shall conform to the requirements of AASHTO M167 for corrugated steel pipe and AASHTO M219 for aluminum alloy pipe.. When asphalt coating is required, it shall be an asphalt mastic applied to the structure after assembly. The asphalt mastic shall conform to the requirements of and be applied in accordance with the requirements of AASHTO M243.
- (e) **Aluminum Alloy Pipe:**
1. **Corrugated aluminum alloy culvert pipe and pipe arches** shall conform to the requirements of AASHTO M196. Material used to produce end sections for use with corrugated aluminum alloy pipe shall conform to the requirements of AASHTO M196.

Aluminum spiral rib pipe used for storm drains shall conform to the requirements of AASHTO M196 except that it shall be of smooth wall, spiral ribbed construction. Connecting bands for aluminum drainpipe shall conform to the thickness and the corrugations or rib of the pipe to which they are connecting.
 2. **Corrugated aluminum alloy pipe underdrains** shall conform to the requirements of AASHTO M196, Type III. When used as combination underdrains, pipe shall not be perforated.
- (f) **Vitrified Clay Pipe and Fittings:** Pipe and fittings shall conform to the requirements of AASHTO M65, extra strength, or, for sanitary sewer, may conform to the requirements of ASTM C700, extra strength. Joints for sanitary sewer shall conform to the requirements of ASTM C425. Plain and perforated clay pipe for drain fields shall conform to the requirements of ASTM C700, extra strength.

(g) **Polyvinylchloride (PVC) Pipe:**

1. **PVC water and pressure sewer pipe** shall conform to the requirements of AWWA C-900, PC-150, for water facilities and ASTM D1785 for pressure sewers and shall have a pressure rating of at least 150 pounds per square inch.
2. **PVC gravity sewer pipe** shall conform to the requirements of ASTM D3034; SDR35; ASTM F794, Series 46; or ASTM F949.
3. **PVC ribbed pipe for culverts and storm drains** shall conform to the requirements of AASHTO M304 or ASTM F949.
4. **PVC underdrains** shall conform to the requirements of ASTM F758, Type PS 28, or ASTM F949.

(h) **Glass Fiber-Reinforced Epoxy Pipe and Fittings:** Pipe and fittings shall conform to the requirements of ASTM D2996, ASTM D2997, or AWWA C950 with a continuous rating of at least 150 pounds per square inch at 150 degrees F for pipe, fittings, and adhesive joints.

(i) **ABS Pipe:**

1. **ABS semiround underdrain pipe with top shield** shall be at least 4 5/8 inches in diameter with drain holes 1/4 or 3/8 inch in diameter drilled at least 7/8 inch apart under the roof line. Pipe shall weigh at least 0.80 pound per foot. When used as combination underdrains, pipe shall not be perforated.
2. **ABS sewer pipe and fittings** shall conform to the requirements of ASTM D2680 for the type of joints specified and shall have a pressure rating of at least 150 pounds per square inch.

(j) **Polyethylene (PE) Pipe:**

1. **PE corrugated underdrain pipe** shall conform to the requirements of AASHTO M252. Pipe shall be supplied in individual lengths with no lengths shorter than 10 feet. Coil pipe will be permitted only in 4-inch or 6-inch diameters provided it is machine installed. If the pipe starts to recoil during installation, the Contractor shall cease operations until a method of anchoring the pipe in the trench is approved. When used as combination underdrain or outlet pipe, the pipe shall be smooth wall, nonperforated.
2. **PE corrugated culvert pipe** shall conform to the requirements of AASHTO M294. PE pipe used for storm drains and entrances shall conform to the requirements of classification Type S. For all other applications, PE pipe shall be Type C or S.
3. **PE pipe and fittings** shall conform to the requirements of AWWA C-901 for water mains and ASTM D2239, Grade P34, for sanitary sewers and shall have a pressure rating of at least 150 pounds per square inch.

(k) **Copper Water Pipe or Tubing:** Copper water pipe or tubing shall conform to the requirements of ASTM B88 and shall have the cast or wrought pattern. Fittings for concealed soft drawn pipe may be the flared mechanical type. Unions shall be the ground joint type.

- (l) **Polybutylene Pipe and Fittings:** Pipe and fittings shall conform to the requirements of AWWA C902 for water mains and ASTM F809 for sanitary sewers.

SECTION 233—GALVANIZING

233.01—Description

These specifications cover the use and repair of zinc coatings (galvanizing) on a variety of materials.

233.02—Detail Requirements

Galvanizing of fabricated items shall be performed after fabrication.

Galvanized items shall be stored off the ground in a manner that will allow free drainage of water from galvanized surfaces.

- (a) **Galvanizing of iron and steel hardware** shall conform to the requirements of ASTM A153 for the hot-dip process or ASTM B695, Class 50, for the mechanical process.
- (b) **Galvanizing of rolled, pressed, and forged steel shapes, plates, bars, and strips** shall conform to the requirements of ASTM A123.

233.03—Repair of Galvanized Surfaces

Galvanizing surfaces that have been damaged or have uncoated areas shall be repaired in accordance with the requirements of ASTM A780 except that repair materials shall not contain lead or cadmium.

SECTION 234—GLASS BEADS FOR REFLECTORIZING TRAFFIC MARKINGS

234.01—Description

This specification covers glass beads for application on liquid traffic-marking materials so as to produce a reflective surface.

234.02—Detail Requirements

Beads shall be manufactured from glass of a composition designed to be highly resistant to traffic wear and weather. Glass beads shall be spherical in shape and shall conform to the requirements of AASHTO M247, Type 1, except that at least 80 percent of the beads shall be round when tested in accordance with the requirements of ASTM D 1155, Procedure B. Beads shall be essentially free of sharp angular particles, milkiness, and surface scoring or scratching.

SECTION 235—RETROREFLECTORS

235.01—Description

Retroreflectors shall consist of a housing/backing with a retroreflective surface on the front and back, if applicable.

Retroreflectors for delineators and pavement markers, except temporary markers, shall be molded of methyl methacrylate plastic conforming to the requirements of Federal Specification L-P-380, Type I, Class 3.

Retroreflectors for temporary pavement markers shall have a surface consisting of reflective sheeting or a plastic prismatic element. The housing/backing for temporary pavement markers shall be constructed of methyl methacrylate plastic conforming to the requirements of Federal Specification L-P-380, Type I, Class 3.

Retroreflectors for delineators shall be the same color as the adjacent pavement marking. Retroreflectors for pavement markers shall be the same color as the adjacent pavement marking except the backside shall be as follows:

- (a) **One-way markers:** The backside shall be red for white raised and white snowplowable raised pavement markers. The backside shall be blank for recessed, temporary pavement markers and yellow raised and yellow snowplowable raised pavement markers.
- (b) **Two-way markers:** The backside shall match the adjacent pavement marking except on recessed markers, which shall be blank.

235.02—Detail Requirements

- (a) **Steel castings for snowplowable pavement markers** shall conform to the requirements of ASTM A536, hardened to 52-54 RC, and shall weigh approximately 5 1/2 pounds. Keels shall be parallel, approximately 0.70 inch thick by 1.90 inches deep, and shall have notched edges. The forward and rear noses of the casting shall be shaped to deflect snowplow blades. Castings shall retain their hardness after removal of adhesives and other foreign residues or shall be capable of conforming to the specified hardness with additional heat treating to ensure the castings can be recycled.
- (b) **Plastic panels for delineators** shall be at least 0.080 inch thick, have a minimum tensile strength at yield of 5,000 pounds per square inch when tested in accordance with the requirements of ASTM D638, and have minimum impact strengths of 2.0 foot-pounds per inch of notch at -20 degrees F and 14.0 foot-pounds per inch of notch at 73 degrees F when tested in accordance with the requirements of ASTM D256, Method A. The panels shall be flexible and able to recoil to within 5 degrees of vertical after impact. Panels shall not deteriorate when exposed to UV rays, petroleum products, ozone, deicing salts, exhaust fumes, or herbicides.
- (c) **Aluminum panels for delineators** shall be at least 0.064 inch thick conforming to the requirements of ASTM B-209, alloy 5052.

- (d) **Delineators** shall have the retroreflective surface and the housing/backing fused to form a homogenous unit sealed against dust, water, and vapor. Retroreflectors shall show no change in shape or color when subjected to 4 hours in a circulating air oven at 170 degrees F to 180 degrees F. The adhesion system shall be as recommended by the manufacturer.

The specific intensity shall be not less than the following values:

Entrance Angle	Observation Angle	Specific Intensity (cd/FC)	
		Clear	Yellow
0°	0.1°	119	71
20°	0.1°	47	28

- (e) **Raised, recessed, and snowplowable raised pavement markers** shall have a retroreflective surface area of no less than 1.4 square inches, and the slope of the reflective surfaces shall be no less than 30 degrees or more than 33 degrees when measured from the pavement surface. The reflective surface shall be protected with a bonded glass face or coated with a clear acrylic compound that uses a UV inhibitor.

The specific intensity shall be not less than the following values when tested in accordance with VTM-70:

Raised and Recessed Pavement Markers				
Entrance Angle	Observation Angle	Specific Intensity (cd/FC)		
		White	Yellow	Red
0°	0.2°	3.0	1.8	0.75
20°	0.2°	1.2	0.72	0.25

Snowplowable Raised Pavement Markers				
Entrance Angle	Observation Angle	Specific Intensity (cd/FC)		
		White	Yellow	Red
0°	0.2°	4.0	2.4	1.0
20°	0.2°	1.6	0.96	0.4

The crushing strength shall be not less than 4,000 pounds when tested in accordance with VTM-71.

Raised and recessed pavement markers shall be at least 4 inches and not more than 4.75 inches in width and not more than 0.55 inch in height.

Retroreflectors for snowplowable raised pavement markers shall be installed in steel castings conforming to the requirements of (a) herein and shall have a nominal width of 4 inches excluding the castings.

- (f) **Temporary pavement marker** shall have a retroreflective surface of no less than 1.0 square inch. The specific intensity shall be not less than the following values:

Entrance Angle	Observation Angle	Specific Intensity (cd/FC)	
		Clear	Yellow
0°	0.2°	3.0	1.8
20°	0.2°	1.2	0.72

SECTION 236—WOOD PRODUCTS

236.01—Description

These specifications cover structural timber and lumber, miscellaneous wood products, and preservative treatments.

236.02—Detail Requirements

- (a) **Structural timber and lumber** shall conform to the requirements of AASHTO M168. The species and grade of structural lumber shall be as shown on the plans. The Engineer may approve the substitution of another species of equal or greater strength selected from the “Allowable Unit Stresses for Structural Lumber—Visually Graded” of AASHTO’s *Standard Specifications for Highway Bridges* or the supplement to *National Design Specification for Stress-Grade Lumber and Its Fastenings* of the National Forest Products Association.

Except as otherwise specified, the species and grade of structural lumber, timber, and posts for the following applications shall be as follows:

1. Bridges shall be at least 1,550 Fb and:
 - a. 5 inch by 5 inch and larger: Southern Pine, No. 1 Dense
 - b. 2 inch through 4 inch by 2 inch through 4 inch: Southern Pine, No. 2 Dense
 - c. 2 inch through 4 inch by 5 inch and through 6 inch: Southern Pine, No. 1
 - d. 2 inch through 4 inch by 8 inch only: Southern Pine, No. 1 Dense.
 - e. 2 inch through 4 inch by 10 inch only: Southern Pine, Non-Dense Select Structural.
 - f. 2 inch through 4 inch by 12 inch only: Southern Pine, Non-Dense Select Structural.

2. Signs shall be at least 1,100 Fb with material being dressed on all sides and:
 - a. 4 inches and less in the least dimension: Southern Pine, No. 2 Non-Dense.
 - b. Over 4 inches in the least dimension: Southern Pine, No. 1
3. Guardrail shall be at least 1,250 Fb Southern Pine, No. 1 Dense.
 - a. In lieu of sawn posts, round Southern pine posts may be used. Round posts shall have at least an 8-inch diameter at the small end, and the diameter of the larger end shall not exceed that of the smaller end by more than 2 inches or be greater than 12 inches. Round posts shall be drilled and gained to accept the rail element or offset block.
4. Fence shall be Southern Pine, No. 2, for line, corner, and brace units.
5. Signalization and electrical service shall conform to the requirements of ANSI Class 5.1.

Sawn material, both rough and dressed, shall be certified by the mill as to grade and shall be grade marked in accordance with the grading rules and basic provisions of the *American Lumber Standards (PS-20-70)* by a lumber grading or inspection bureau or agency approved by the Department. If dressed, the grade mark shall be applied after dressing.

- (b) **Timber piles** shall conform to the requirements of ASTM D25. Piles shall be clean peeled and have a butt circumference of at least 31 inches. Piles for fender systems or other non-load bearing uses will be accepted under the following criteria provided the piles can be properly driven: A straight line from the center of the butt to the center of the tip may lie partly outside the body of the pile, but the distance between the line and pile shall be not more than 1/2 percent of the length of the pile or 3 inches, whichever is smaller.

Points for timber piles shall be steel or cast iron and of a shape that will allow a secure connection to the pile and will withstand driving.

Timber piles shall be branded prior to shipment with the supplier brand, year of treatment, species of timber and preservative treatment, retentions, class, and length. Brand symbols shall conform to the requirements of AWP A M6.

- (c) **Timber preservatives** shall be used according to their suitability for the condition of exposure to which they will be subjected and shall not be used interchangeably. Treatments shall conform to the following limitations:
1. Waterborne preservatives shall be used for timber where a clean surface is desirable. The moisture content of wood material shall be not more than 19 percent at the time of treatment.
 2. Pentachlorophenol and creosote may be used for timber that is not to be painted. Timbers treated with pentachlorophenol or creosote shall be free of excess preservative on the wood surface.

3. Preservatives shall conform to the requirements of the American Wood-Preservers' Association (AWPA).
4. Pressure treatment shall conform to the requirements of the AWPA "Use Category System" as follows:
 - Lumber and timber for bridge structures including bridge decking, guardrail posts, and offset blocks shall be treated to conform to the requirements of UC4B.
 - Foundation piles shall be treated to conform to the requirements of UC4C.
 - Wood composites shall be treated to conform to the requirements of UC4A.
 - Sign posts, fence posts, and gates shall be treated to conform to the requirements of UC4A.
 - All other sawn products and round posts less than 16 feet in length shall be treated to conform to the requirements of UC4A.
5. Marine applications where wood structures or products will be placed in or above salt water, brackish water, or tidal water shall be treated to conform to the requirements of UC5B.
6. Wood used for highway construction and maintenance applications for sign posts, fence posts, wood posts, guardrail posts, bridge decking, gates, stair treads, and offset blocks shall be treated with a chromated copper arsenate (CCA) preservative. Wood used for highway construction and maintenance applications for piles, timbers, and composites may be treated with a CCA, pentachlorophenol, or creosote preservative.
7. Wood used for hand-contact surfaces such as handrails, playground equipment, and picnic tables shall be treated with either ammoniacal copper quaternary (ACQ) salt or copper azole (CA) preservative. ACQ and CA wood treatments are highly corrosive to metal; fasteners or connectors that will be in contact with wood using ACQ or CA wood preservative treatments shall be either 304 or 316 stainless steel or hot-dipped galvanized steel that conforms to the requirements of ASTM A153 or ASTM A653, Class G185. Mechanically galvanized steel is prohibited.

SECTION 237—BEDDING MATERIAL AND BEARING PADS

237.01—Description

These specifications cover material used under bearing devices of structures.

237.02—Detail Requirements

- (a) **Elastomeric Bearing Pads:** The elastomer portion of pads shall be new neoprene compound. Pads shall be cast under heat and pressure and may be individually molded or cut

from pressure-cast stock. Variations from the dimensions shown on the plans shall be not more than the following: thickness, $\pm 1/16$ inch; width, $-1/8$ to $+1/4$ inch; length, $-1/8$ to $+1/4$ inch. Tolerances, dimensions, finish and appearance, flash, and rubber-to-metal bonding shall conform to the requirements of A 4-F3-T.063-B2, Grade 2, Method B, in accordance with the *RMA Rubber Handbook*. Pads shall be furnished in one piece and shall not be laminated unless otherwise specified. Pads shall be furnished in identifiable packages.

Adhesive for use with elastomer pads shall be an epoxy-resin compound, compatible with the elastomer, having a sufficient shear strength to prevent slippage between pads and adjacent bearing surfaces.

Laminated pads shall consist of alternate laminations of elastomer and hot-rolled steel sheets molded together as a unit. The bond between the elastomer and metal shall be such that failure shall occur in the elastomer and not between the elastomer and steel when tested for separation.

Material having a nominal durometer hardness of 70 and 50 shall be used for nonlaminated pads and laminated pads, respectively. Test samples will be prepared from finished pads. Samples of each thickness will be taken from 2 full-size pads from each shipment of 300 pads or less, with 1 additional pad for each additional increment of 300 pads or fraction thereof. When tested in accordance with the ASTM methods designated, samples shall comply with the following physical requirements.

1. **Original physical properties:** Test results for tear resistance, tensile strength, and ultimate elongation shall be not more than 10 percent below the following specified value:

Property	Nominal 50	Hardness 70
Min. tear resistance, ASTM D624, Die C (lb/in of thickness)	180	200
Hardness, ASTM D2240 (points)	50 ± 5	70 ± 5
Min. tensile strength, ASTM D412 (average psi of longitudinal and transverse)	2,500	2,500
Min. ultimate elongation (%)	400	300

The compressive deflection tested in accordance with the requirements of ASTM D575, Method A, shall be as follows:

- a. **Laminated pads:** The maximum compressive deflection shall be 7 percent of the total rubber thickness at the total load given in the plans. The maximum shear resistance shall be 50 pounds per square inch of the plan area at 25 percent shear deformation at -20 degrees F. Test pads shall be subjected to a compressive load of 1.5 times the maximum design load without visible damage.
 - b. **Nonlaminated pads:** When loaded within 300 to 800 pounds per square inch, material shall show a compressive deflection within 20 percent of that given in the charts of VTM-23, interpolating for actual measured hardness.
2. **Changes in original physical properties:** When pads are oven aged 70 hours at 212 degrees F in accordance with the requirements of ASTM D573, changes shall be not more than the following:

Property	Value
Hardness (points change)	0 to +15
Tensile strength (% change)	±15
Ultimate elongation (% change)	-40

3. **Extreme temperature characteristics:** Compression set under constant deflection in accordance with the requirements of ASTM D395, Method B, 22 hours at 212 degrees F, shall be not more than 35 percent. When tested in accordance with the requirements of the low temperature brittleness test, ASTM D746, breaks shall not occur above -20 degrees F.
4. **Ozone cracking resistance:** Upon exposure to 100 parts per million of ozone in air by volume at a strain of 20 percent and a temperature of 100 ± 2 degrees F in a test conducted otherwise in accordance with the requirements of ASTM D1149, cracks shall not develop within 100 hours. Samples shall be wiped with solvent before the test to remove traces of surface impurities.
5. **Oil swell:** The volume change shall be not more than +120 percent when tested in accordance with the requirements of ASTM D471 with ASTM Oil No. 3, 70 hours at 212 degrees F.

(b) **TFE Bearing Surfaces:**

1. TFE resin shall be virgin material conforming to the requirements of ASTM D1457. The specific gravity shall be 2.13 to 2.19. The melting point shall be 623 ± 2 degrees F.
2. Filler material shall be milled glass fibers, carbon, or other approved inert filler materials.
3. Adhesive material shall be an epoxy resin conforming to the requirements of FS MMM-A-134, FEB film or equal, as approved by the Engineer.
4. When tested in accordance with the requirements of ASTM D1457, finished unfilled TFE sheets shall have a tensile strength of at least 2,800 pounds per square inch and an elongation of at least 200 percent.
5. Filled TFE sheets shall contain inert filler material uniformly blended with TFE resin. Finished filled TFE sheets containing glass fiber or carbon shall conform to the following:

	ASTM Method	15% Glass Fibers	25% Carbon
Min. tensile strength	D1457	2,000 psi	1,300 psi
Min. elongation	D1457	150%	75%
Min. specific gravity	D792	2.20	2.10
Melting point	D1457	$621 \pm -50^\circ\text{F}$	$603 \pm -50^\circ\text{F}$

6. Fabric containing TFE fibers shall be manufactured from oriented multifilament TFE fluorocarbon fibers and other fibers as required by specific designs. When tested in ac-

cordance with the requirements of ASTM D2256, the tensile strength of TFE fibers shall be at least 24,000 pounds per square inch and the elongation shall be at least 75 percent.

7. Where TFE sheets are to be epoxy bonded, one surface of the sheet shall be factory treated by an approved manufacturer using the sodium naphthalene or sodium ammonia process.
8. Stainless steel mating surfaces shall be at least 16 gage in thickness and shall conform to the requirements of ASTM A240, Type 304. The mating surface shall be a true plane surface with a Brinell hardness of at least 125 and a surface finish of at least No. 8 mirror finish in accordance with the requirements of ASTM A480. Stainless steel mating surfaces shall be polished or rolled as necessary to conform to the friction requirements specified herein. The stainless steel shall be attached to the sole plate by means of a seal weld around the entire perimeter of the facing material.
9. The coefficient of friction for the completed bearing assembly shall be not more than the following:

Material	Bearing Pressure		
	500 psi (3.447 MPa)	2,000 psi (13.790 MPa)	3,500 psi (24.132 MPa)
Unfilled TFE, fabric containing TFE fibers, TFE perforated metal composite	.08	.06	.04
Filled TFE	.12	.10	.08
Interlocked bronze and filled TFE structures	.10	.07	.05

- (c) **Sheet Lead and Common Desilverized Bedding Material:** Material shall conform to the requirements of ASTM B749 and shall be furnished in single sheets of the specified thickness.
- (d) **Preformed Fabric Bedding Material:** Material shall be composed of multiple layers of 8-ounce cotton duck impregnated and bound with high-quality natural rubber or its equivalent and equally suitable materials compressed into resilient pads of uniform thickness. The number of plies shall be such as to produce the specified thickness after compression and vulcanizing. Finished pads shall withstand compression loads perpendicular to the plane of the laminations of at least 10,000 pounds per square inch without a detrimental reduction in thickness or extrusion.

SECTION 238—ELECTRICAL AND SIGNAL COMPONENTS

238.01—Description

These specifications cover conduits, conductors, junction boxes, traffic signal components, and necessary fittings to complete a described electrical or traffic signal system.

238.02—Detail Requirements

- (a) **Metal Conduit and Fittings:** Conduit shall conform to the requirements of and be galvanized in accordance with the requirements of UL-6. Fittings for metal conduit shall conform to the requirements of and be galvanized in accordance with the requirements of UL-514. Conduit for use in underground installations, concrete encasements, or corrosive environments shall also be coated on the outside with an asphalt mastic in accordance with the requirements of AASHTO M243 or shall have a PVC coating of 40 mils or another approved coating.
- (b) **PVC Conduit and Fittings:** Conduit shall be heavy wall conduit conforming to the requirements of UL-651. Fittings for PVC conduit shall conform to the requirements of UL-514. Exposed PVC conduit shall be UL listed or ETL Testing Laboratories, Inc., listed for use in direct sunlight. Each section of conduit shall be marked with the letters UL or ETL. Solvent cement used for joining shall conform to the requirements of ASTM D2564. Protective shields shall be galvanized sheet steel of commercial quality with a coating designation conforming to the requirements of ASTM A525, coating designation G115, and a thickness of 0.0625 inch.

When used in a directional boring operation, PVC conforming to the requirements of Schedule 40 shall have integral male/female couplings, a gasket, locking rings, and grooves designed to secure the conduit sections for installation in the bored area. Joints shall have a pull rating of 7,000 pounds for 3-inch conduit, 8,700 pounds for 4-inch conduit, 11,300 pounds for 5-inch conduit, and 14,000 pounds for 6-inch conduit.

- (c) **Fiberglass-reinforced Epoxy Resin Conduit and Fittings:** Conduit shall conform to the requirements of NEMA TC-14B. Conduit used in exposed areas shall be heavy wall and sunlight resistant. Epoxy adhesive used for joining shall conform to the requirements of NEMA TC-14. Protective shields shall conform to the same requirements as those with PVC conduit.
- (d) **PE Conduit:** PE conduit shall conform to the requirements of NEMA TC-7 for high-density PE duct except that the wall thickness of conduit with a diameter of 1 1/4 inches and less shall conform to the requirements of UL-651 for heavy-wall PVC conduit. Conduit shall have a carbon black loading of 2.5 ± 0.5 percent by weight in accordance with ASTM D1603. The average diameter of the carbon black shall be no larger than 40 millimicrons in accordance with the requirements of ASTM D1514. Conduit shall contain at least 1,000 parts per million of hindered phenolic long-term antioxidant in accordance with the requirements of ASTM D3895.
- (e) **Splice Boxes or Pull Boxes (512 cubic inches or less):** Boxes will be permitted only in exposed areas and shall conform to the requirements of UL-514 and be compatible with the appropriate conduit.
- (f) **Electrical and Signal Junction Boxes:** Boxes, frames, and covers shall be watertight except for weep holes. Covers shall be fitted with synthetic rubber blend gaskets and secured with bronze or stainless steel screws.

Boxes, frames, and covers for bridge structure encasements shall be one of the following types:

- steel castings conforming to the requirements of Section 224, galvanized inside and out
- welded sheet steel having a thickness of at least 3/16 inch or 7 gage, galvanized inside and out
- polymer concrete with fiberglass sides

Boxes, frames, and covers for other uses shall withstand H-20 loading in accordance with the requirements of AASHTO's *Standard Specifications for Highway Bridges* HS20-44. Boxes shall be one of the following types:

- polymer concrete with fiberglass sides
- cast iron with an asphalt mastic coating on exterior surfaces, except the cover, conforming to the requirements of AASHTO M243 or other protective coating materials specifically manufactured for use in corrosive environments as approved by the Engineer
- concrete conforming to the requirements of Section 217
- 1/4-inch steel plate conforming to the requirements of ASTM A36, galvanized in accordance with the requirements of Section 233, and uniformly coated on exterior surfaces, except the cover, with an asphalt mastic conforming to the requirements of AASHTO M243

Alternate types of boxes may be submitted for review provided they conform to the following:

- Boxes shall withstand H-20 loading in accordance with AASHTO's *Standard Specifications for Highway Bridges* HS20-44.
- Material shall be fire resistant and shall not burn at a rate greater than 0.3 inch per second per 0.1 inch of thickness when tested in accordance with the requirements of ASTM D635.
- Material shall have an absorption rate less than the requirement for a concrete pipe specified in Section 232.02(a)1.b(7).
- Material shall show no appreciable change in physical properties after exposure to weather, oil, gasoline, or snow removal chemicals.

(g) Conductor Cables:

1. **Power conductor cables** shall be copper conforming to the requirements of ASTM B3 and B8. Conductor cable sizes shall be based on No. 8 AWG minimum. Conductor cables of No. 8 AWG and larger shall be stranded. Conductor insulation shall be UL listed for the use specified on the plans and rated for 600-volt operation.
 - a. **Service entrance conductor cables** shall be UL with Type SE insulation.

- b. **Underground service entrance conductor cables** shall be UL with Type USE insulation.
- c. **Direct burial conductor cables** shall be UL with Type USE or UF insulation.
- d. **Conductor cables in conduit** shall be UL with Type THWN insulation except as follows: When the conduit size specified on the plans is such that the allowable percentage of conduit fill in Table 1, Chapter 9, of NEC is not exceeded, then UL Type RHW, TW, THW, XHHW, or XLPE insulation may be used.

Where direct burial conductor cables enter a conduit, they may be spliced to THWN conductor cables only at accessible locations.

2. **Communication and signal cables:**

- a. **Signal cables from the controller cabinet to signal heads** shall be No. 14 AWG copper with 3, 4, 7, or 12 straight-lay conductors conforming to the requirements of IMSA 19-1 or 20-1, aerial and duct, or 19-5 or 20-5, direct buried. Signal cable used for preemption or pedestrian pushbuttons shall be two-conductor No. 14 AWG conforming to the requirements herein.
- b. **Interconnect cables between controllers** shall be No. 14 AWG solid copper conforming to the requirements of IMSA 19-2 or 20-2, aerial and duct; 19-4 or 20-4, self-supporting aerial; or 19-6 or 20-6, direct buried. When interconnect cable is specified to be either No. 18, 19, or 22 AWG, it shall be solid copper conforming to the requirements of IMSA 39-2 or 40-2, aerial and duct; 39-4 or 40-4, self-supporting aerial; or 39-6 or 40-6, direct buried.
- c. **Loop detector cables** shall be No. 12 AWG stranded copper conforming to the requirements of IMSA 51-3. Insulation shall be Type XHHW. Loop detector cable enclosed in tubing shall be No. 14 AWG stranded copper. Loop detector cable and tubing shall conform to the requirements of IMSA 51-5.
- d. **Loop and magnetic detector lead-in cables** shall be stranded copper, twisted pair, No. 14 AWG conforming to the requirements of IMSA 50-2.

(h) **Electrical Components:**

- 1. **Safety switches** shall be enclosed in a rain-tight metal box and cover conforming to the requirements of NEMA 3R, with a lock-on/lock-off external switch handle. Safety switches shall be heavy duty, two-pole minimum with solid neutral and fused compatible with the equipment load. For signal installations, safety switches shall be rated at 100 amp/240 volts.
- 2. **Circuit breaker boxes** used as a service disconnect for signal equipment shall be a rain-tight metal box and cover conforming to the requirements of NEMA 3R. The circuit breaker box shall be rated at 100 amp/240 VAC with a solid neutral and shall contain two single-pole, 120-VAC breakers with an ampere rating compatible with the equipment load and shall have provisions for padlocking. The service load shall be wired to only one breaker.

3. **Grounding electrodes (rods)** shall be copper-clad rods conforming to the requirements of UL-467. Grounding electrodes shall have a diameter of 3/4 inch and a length of 10 feet. Grounding electrodes couplers shall be bronze, stainless steel, or copper clad with a solid center providing 100 percent conductivity and be UL approved.
4. **Grounding electrode conductors** shall be no less than No. 6 AWG (bare solid wire) conforming to the requirements of ASTM B2.
5. **Ground clamps** shall be heavy-duty bronze or brass or galvanized malleable iron conforming to the requirements of ASTM A220, any grade.
6. **Signal head sections:**
 - a. **Standard traffic signal head sections** shall conform to the ITE Standard for Vehicle Traffic Control Signal Heads with the following exceptions and additions:
 - (1) Lenses shall be made of glass.
 - (2) Reflectors shall be made of glass or aluminum and shall be attached to the signal head housing by a hinged support system that is separate from the door and lens.
 - b. **Selective view signal head sections** shall conform to the requirements of Section 4.04 of the ITE Standard for Vehicle Traffic Control Signal Heads.
 - c. **Pedestrian signal head sections** shall be made of plastic, nonferrous metal, or a combination thereof. Strength requirements shall conform to the ITE Standard for Vehicle Traffic Control Signal Heads. The displays shall include “Walking Person” and “Upraised Hand” symbol indications in a separate or overlay configuration. Indications shall be illuminated using light emitting diode (LED) modules and shall conform to the latest ITE Performance Specifications for Pedestrian Traffic Control Signal Indications. Symbol indications shall be filled.

The Contractor shall provide with the initial catalog cut submittals for the model and type of pedestrian signal furnished the manufacturer’s certificate of ITE compliance and an independent photometric laboratory certification for ITE luminous intensity requirements for the LED modules.

- d. **Lane use control signal head sections** shall conform to the ITE Standard for Lane Use Traffic Control Signal Heads with the following exceptions and additions:
 - (1) Strength requirements shall conform to the ITE Standard for Vehicle Traffic Control Signal Heads.
 - (2) Lenses shall be made of glass.
 - (3) Reflectors shall be attached to the signal head housing by a hinged support system that is separate from the door and lens.

- e. **Signal lamps** shall conform to the requirements of the ITE standards for Traffic Signal Lamps and shall contain no less than 89 percent Krypton gas. The manufacturer shall provide certification of ITE compliance and percentage of Krypton gas from an independent testing laboratory.
- f. **LED traffic signal head sections** shall consist of a standard traffic signal head section without the optical assembly and a LED vehicle traffic signal module.

LED circular traffic signal modules shall conform to the requirements of the ITE Vehicle Traffic Control Signal Heads—Light Emitting Diode Circular Signal Supplement issued on June 27, 2005 (inclusive of any ITE documents that amend, revise, and/or supersede it).

LED arrow traffic signal modules shall conform to the requirements of the ITE Vehicle Traffic Control Signal Heads—Part 3: Light Emitting Diode Vehicle Arrow Traffic Signal issued on September 8, 2003, and adopted in March 2004 (inclusive of any ITE documents that amend, revise, and/or supersede it).

The Contractor shall provide the LED manufacturer's certificate of ITE compliance for the LED modules furnished and independent laboratory test reports. Independent laboratory tests shall include specific test and test results of each ITE test as specified in the ITE Design Qualification Testing Section 6.4. Independent test reports shall be submitted at the same time as the catalog cut is submitted for the model and type of LED signal module furnished.

The Independent laboratory used for LED testing shall be on OSHA's current list of Nationally Recognized Test Laboratory(s) (NRTLs). The testing laboratory shall be located within the continental United States or Canada.

LED modules shall be fully compatible with the features and functions of conflict monitors and malfunction management units. Compatibility shall include, but not be limited to, dual indication, absence of red, and conflict monitoring. The Contractor shall verify the compatibility of LED modules in the presence of the Engineer.

The LEDs shall be mounted and soldered to a printed circuit board. Modules shall be provided with an external in-line fuse (fusing AC hot). The LED signal module shall use the same mounting hardware used to secure the incandescent lens and gasket assembly and shall require only a screwdriver or standard installation tool to complete the mounting.

The control circuitry shall prevent the current flow through the LEDs in the off state to avoid any false indication as may be perceived by the human eye during daylight and evening hours.

The manufacturer's part number, model and manufacturing date of the LED signal module shall be visible on the rear of the assembly.

LED traffic signal modules shall be warranted for 5 years against manufacturing defects. Modules shall be replaced if the module fails due to material and/or workmanship during this 5-year period.

7. **Backplates for signal heads:**

- a. **Virgin ABS plastic** shall contain 60 percent styrene, 20 percent rubber, and 20 percent acrylic, with a thickness of at least 0.125 inch. Plastic shall contain ultra-violet inhibitors and stabilizers and shall be compounded for application in cold weather. Plastic shall have a tensile stress at yield of at least 5,300 pounds per square inch at 73 degrees F and a flexural strength at yield of at least 9,300 pounds per square inch at 73 degrees F. Plastic shall conform to or exceed the requirements of UL-94 test H.B. for fire retardance. The color of backplates shall be impregnated into the plastic. Backplates shall be vacuum formed; the inside and outside edges shall be formed with at least a 1/2-inch flange turned away from the front surface.

8. **Cable clamps:**

- a. Two bolt clamps shall be 4 inches in length, made to accommodate span wire ranging from 1/4 to 7/16 inch in diameter, and shall conform to the requirements of NEMA PH-23 except for clamp dimensions.
- b. Three bolt clamps shall be the heavy 6-inch length type conforming to the requirements of NEMA PH-23 except the clamp dimensions shall be as required to accommodate span wire ranging from 3/8 to 5/8 inch in diameter.

9. **Cable rings and lashing wires** shall be weather resistant and the industry standard.

10. **Connectors and terminals** shall conform to the requirements of NEC 110. Breakaway connectors shall consist of line and load side sections designed to separate without breaking the conductor. Connectors shall be waterproof with an insulation rating of 600 volts. Current carrying components exposed when the connector is separated shall be in the load section of the connector. Connectors for the hot conductors shall be designed for 13/32 inch by 1 1/2 inch cartridge type fuses. Fuses shall be rated at 10 amps.

11. **Angle thimbles** shall be Rural Utilities Service (RUS) listed.

12. **Span wire saddle clamps** for span wire connection on a bridle span shall use U-bolts for securing the clamp to the span wire and shall be galvanized malleable iron with a tensile strength of 25,000 pounds.

13. **Stainless steel straps** shall be solid, 5/8 inch width minimum, with a tensile strength of at least 100,000 pounds per square inch.

14. **Service entrance heads** shall be galvanized malleable iron.

15. **Tether wire** shall conform to the requirements of ASTM A475, Common Grade, Class A, seven strand, or Type I, General Purpose, Class I, 6 x 7, iron, galvanized, fiber core, conforming to the requirements of FS RR-W-00410C. The breaking strength of tether cable shall be not more than 3,000 pounds.

16. **Thimbleye bolts** shall conform to the requirements of ANSI C135.4 and the following:

- a. The tensile strength shall be at least 18,350 pounds for 3/4-inch bolts.
- b. Dimensions for 3/4-inch bolts shall comply with the following as related to Figures 1 and 2 in ANSI C135.4:

Bolt Diameter	A	D	E
3/4 in	13/16 in	9/32 in	11/32 in

17. **Thimbleye nuts** shall conform to the requirements of ANSI C135.4.
18. **Washers for use with thimbleye bolts** shall conform to the requirements of NEMA PH-10.
19. **Tape:**
 - a. **Vinyl tape** shall be for electrical use and shall conform to the requirements of ASTM D2301, Type 1.
 - b. **Rubber tape** shall be for electrical use and shall conform to the requirements of ASTM D4388.
20. **Photoelectric controls** shall conform to the requirements of ANSI C136.10 and the following. The photoelectric control shall be solid state, fail-on type, single-voltage rated and shall be factory preset and calibrated to turn on at 1.5 footcandles \pm 0.5 foot-candle. The ratio of the turn-off light level to the turn-on light level shall not exceed 1.65:1. The photoelectric control shall use a cadmium sulfide sensor. The output control relay shall have a time delay of 5 to 15 seconds. The photoelectric control shall have a built-in 160-joule metal oxide varistor for surge/transient protection. The contact shall be mechanical, and contact "chatter" upon opening of the contacts shall not exceed 5 milliseconds. The cover shall be an impact- and ultraviolet-resistant material that complies with the flammability and impact requirements of UL-773. The window shall be made of acrylic with the proper ultraviolet stabilizers added to prevent discoloration. The control shall be capable of withstanding a drop of 3 feet onto a concrete floor without causing damage to the housing or changing the electrical operation.
21. **Miscellaneous signal line hardware and/or attachments** shall be galvanized or stainless steel.
22. **Span wires** shall conform to the requirements of ASTM A475, High-Strength Grade, Class A.
23. **Splice kits** shall be packaged containing materials from a single supplier and shall consist of a plastic molded body with a compound that provides a water-resistant seal and insulation for the conductor cables for at least 600 volts.
24. **Span wire clamps** for signal head mounting shall use U-bolts for securing the clamp to the span wire and shall be galvanized malleable iron or aluminum with a tensile strength of 6,000 pounds.

25. **Contactors** shall be UL listed, open type. The contactor shall be rated to be compatible with the equipment load and type of load
26. **Dead-end strain vise clamps** shall be designed for the size of the span wire or tether wire and their tensile strength shall be the same as or exceed the tensile strength of the cable. Clamps shall be fabricated from corrosion-resistant materials or shall be galvanized. Clamps shall have a release slot for holding the jaws back for retensioning and removal of the wire. Clamps shall be internally coated with inhibitor oils to prevent corrosion and to allow for the free movement of the jaws.
27. **Heat-shrink tubing** shall consist of an adhesive-lined, polyolefin flexible material conforming to the following requirements:
- | | |
|-------------------|-------------|
| Shrinkage ratio | 2:1 |
| Water absorption | 0.3% max. |
| Electrical rating | ≥ 600 volts |
28. **Guy markers** shall be white, unless otherwise specified, and shall be PVC or polyolefin complete with all necessary manufacturer-approved installation/mounting hardware and shall conform to the following minimum requirements:

Property	Test Method	Unit	Materials	
			PVC	Polyolefin
Mechanical				
Tensile strength	ASTM D638	psi (MPa)	6,500 (45)	4,500 (31)
Tensile modulus	ASTM D638	psi (MPa)	380,000 (2617)	141,000 (971)
Hardness, Shore D	ASTM D2240/D2583	N/A	78	68
Notched impact	ASTM D256	ft-lb/in (J/m)	11.0 (587)	5.0 (267)
Thermal				
Heat distortion temperature at 264 psi (1.8 MPa)	ASTM D648	degrees F degrees C	162 72	N/A N/A
Flammability	UL-94		V-O	N/A
Electrical				
Dielectric constant	ASTM D150	Volts per mil of thickness	3.5	2.3
Dielectric strength	ASTM D149	Volts per mil of thickness	480	500

SECTION 239—SODIUM CHLORIDE AND CALCIUM CHLORIDE

239.01—Description

These specifications cover chloride used as a stabilizer or to control snow and ice.

239.02—Detail Requirements

- (a) **Sodium chloride** shall conform to the requirements of AASHTO M143, Type I, with the following exceptions:
1. The sodium chloride content shall be at least 97 percent of the dry weight.
 2. The moisture content shall be not more than 5 percent.
 3. When shipped in bulk, sodium chloride shall contain an anticaking additive.
 4. Sodium chloride will be tested in accordance with the requirements of VTM-28.

When practicable, samples will be taken at the source from indoor storage or adequately protected outdoor storage at the rate of approximately one sample per 4,000 tons. Samples will not be taken from uncovered storage.

When inspection at the source is not practicable or when material is shipped from uncovered storage, samples will be taken at the destination at the time of delivery.

When shipments of sodium chloride are made from approved stock at the source, inspection service will be provided when the frequency of shipments makes it economically justified. This inspection will be indicated by the Inspector's stamp on the shipping or delivery report. When inspection service is not provided, the supplier may ship but shall certify that the material came from an approved source. The certification may be stamped on the shipping or delivery report but shall be signed by an authorized representative of the company.

- (b) **Calcium chloride** shall conform to the requirements of AASHTO M144.

SECTION 240—LIME**240.01—Description**

These specifications cover lime to be used as a stabilizer or soil conditioner.

240.02—Detail Requirements

- (a) **Hydrated lime** shall conform to the requirements of ASTM C207, Type N, except that the average percentage of calcium oxide shall be at least 93. Single test results shall not be below 90 percent.
- (b) **Hydraulic lime** shall conform to the requirements of ASTM C141.
- (c) **Agricultural lime:**

1. **Ground limestone** shall be of such fineness that at least 86 percent will pass a No. 20 mesh screen, at least 47 percent will pass a No. 60 mesh screen, and at least 28 percent will pass a No. 100 mesh screen. Material shall have a calcium carbonate equivalent of at least 85 percent.
 2. **Pulverized limestone** shall be of such fineness that at least 90 percent will pass a No. 20 mesh screen and at least 66 percent will pass a No. 100 mesh screen. Material shall have a calcium carbonate equivalent of at least 85 percent.
- (d) **Lime for soil stabilization** shall be quicklime or hydrated lime conforming to the requirements of AASHTO M216.

SECTION 241—FLY ASH

241.01—Description

These specifications cover fly ash (burnt coal residue) used as an additive in hydraulic cement concrete or as a soil stabilizer.

241.02—Detail Requirements

- (a) **Fly ash used in hydraulic cement concrete** shall conform to the requirements of ASTM C618, Class F or Class C.
- (b) **Fly ash used in lime stabilization** shall conform to the requirements of ASTM C593. Bulk material may be used as approved by the Engineer.

SECTION 242—FENCES

242.01—Description

These specifications cover material requirements for fence components used in the construction of chain link, pedestrian, barbed wire, woven wire, and lawn fences and material specifications for temporary silt fences, geotextile fabric silt barriers, and filter barriers used for erosion control.

242.02—Detail Requirements

Steel posts and braces for standard fence and chain link fence may be fabricated from pregalvanized material in lieu of galvanization after fabrication provided ends and other areas of exposed metal are satisfactorily repaired using a material conforming to the requirements of Section 233.

- (a) **Chain Link and Pedestrian Fences:** Fabric material shall be 9-gage core, new, and shall conform to the following:

1. **Galvanized wire fabric for use in chain link fence** shall be hot-dip galvanized after weaving in accordance with the requirements of AASHTO M181, Type I, Class D, and for use in pedestrian fence shall be hot-dip galvanized after weaving in accordance with the requirements of AASHTO M181, Type I, Class C.
2. **Aluminum alloy wire fabric** shall conform to the requirements of AASHTO M181, Type III.
3. **Aluminum-coated wire fabric** shall conform to the requirements of AASHTO M181, Type II.
4. **Coated wire fabric:**
 - a. **Vinyl-coated wire fabric** shall conform to the requirements of AASHTO M181, Type IV, Class A or Class B, except that vinyl coated may be No. 9 gage overall, including the vinyl coating, provided that the core wire has a minimum zinc coat weight of 0.30 ounce per square foot and a minimum breaking strength of 1,290 pounds force.
 - b. **Other conforming organic polymer-coated wire fabric** shall conform to the requirements of ASTM F 668 Class 1, Class 2a or 2b.
5. **End, corner, and gate posts** shall be one of the following:
 - a. welded or seamless steel galvanized pipe conforming to the requirements of ASTM F1083, Schedule 40
 - b. roll-formed steel sections conforming to the requirements of ASTM F1043, Group IIA Type A
 - c. aluminum alloy pipe conforming to the requirements of ASTM F1043, Group IB
 - d. galvanized pipe conforming to the requirements of ASTM F1043, Group IC, with Type B external coating and Type D internal coating
 - e. vinyl or other conforming organic polymer-coated pipe conforming to the requirements of ASTM F1043, Group IA, with Type A external and internal coatings
 - f. vinyl or other conforming organic polymer-coated pipe conforming to the requirements of ASTM F1043, Group IC, with Type B external coating and Type D internal coating
6. **Line posts** shall be one of the following:
 - a. steel H-columns conforming to the requirements of ASTM F1043, Group III, Type A
 - b. round galvanized steel pipe conforming to the requirements of ASTM F1083, Schedule 40

- c. roll-formed C-sections conforming to the requirements of ASTM F1043, Group IIA, Type A
 - d. aluminum alloy H-columns conforming to the requirements of ASTM B221, alloy 6063-T6
 - e. aluminum alloy pipe conforming to the requirements of ASTM F1043, Group IB
 - f. galvanized pipe conforming to the requirements of ASTM F1043, Group IC, with Type B external coating and Type D internal coating
 - g. vinyl or other conforming organic polymer-coated pipe conforming to the requirements of (a)5.e. or (a)5.f. herein
7. **Braces** shall be one of the following:
- a. welded or seamless steel galvanized pipe conforming to the requirements of ASTM F1083, Schedule 40
 - b. roll-formed steel sections conforming to the requirements of ASTM F1043, Group IIA, Type A
 - c. aluminum alloy pipe conforming to the requirements of ASTM F1043, Group IB
 - d. galvanized pipe conforming to the requirements of ASTM F1043, Group IC, with Type B external coating and Type D internal coating
 - e. vinyl or other conforming organic polymer-coated pipe conforming to the requirements of (a)5.e. or (a)5.f. herein
8. **Gates** shall be complete with hinges, latches, stops, and other necessary fittings. Gate frames shall be fabricated and coated with the same material as the adjoining fence framework and fabric.
9. **Aluminum alloy post surfaces that will be in contact with concrete and up to 1 inch above concrete** shall be uniformly coated with an aluminum-impregnated caulking compound or a solvent asphalt-fiber-filled and aluminum-pigmented coating conforming to the requirements of ASTM D2824, Type III. Care shall be taken to prevent voids in the coating and the smearing of visible surfaces of concrete or posts except as otherwise noted herein.
10. **Tension wire** shall conform to one of the following:
- a. aluminum-coated tension wire conforming to the requirements of AASHTO M181
 - b. zinc-coated tension wire conforming with the requirements of AASHTO M181, Class 1
 - c. vinyl-coated tension wire conforming to the requirements of AASHTO M181, Class A or Class B. The core wire shall be 6 or 7 gage, with a tolerance of ± 0.005

inch. The minimum weight of the zinc coating shall be 0.40 ounce per square foot. The breaking strength of the core wire shall conform to the requirements of AASHTO M181 for tension wire.

- d. other conforming organic polymer-coated tension wire shall be 6 or 7 gage with a tolerance of ± 0.005 inch and conform to the requirements of ASTM F1664. The breaking strength of the core wire shall conform with the requirements of AASHTO M181 for tension wire.

11. **Fittings** shall be fabricated and coated with the same material as the fence framework and fabric.

12. **Temporary safety fence** shall comply with the following requirements:

- a. The tensile yield determined in accordance with the requirements of ASTM D638 shall be an average of 2,000 pounds per 4-foot width.
- b. The ultimate tensile strength determined in accordance with ASTM S 638 shall be an average of 2,900 pounds per 4-foot width.
- c. The elongation at break shall be greater than 1,000 percent.

(b) **Barbed Wire Fence, Woven Wire Fence, and Lawn Fence:**

1. **Barbed wire** shall conform to one of the following:

- a. ASTM A121, Coating Type Z, Coating Class 3 Design Number 12-4-5-14R
- b. ASTM A121, Coating Type Z, Design Number 15-4-5-16R except that the tensile strength of the line wire shall be at least 475 pounds per strand and the zinc coating shall be at least 0.70 ounce per square foot
- c. single-strand oval-shaped wire having a diameter of at least 0.08 inch in its least dimension but not more than 0.135 inch in its greatest dimension and a tensile strength of at least 1150 pounds; wire shall have four barbs of 14-gage wire and a zinc coating of at least 0.30 ounce per square foot.
- d. vinyl and other polymer-coated barbed wire conforming to the requirements of ASTM F1665, Type I

2. **Woven wire fence fabric** shall conform to the requirements of AASHTO M279. Standard FE-W1 woven wire fence fabric shall conform to the requirements of Design No. 1047-6-11, Class 3, or No. 1047-6-12 1/2, Grade 125, Class 3. Standard FE-W2 woven wire fence fabric shall conform to the requirements of Design No. 1047-12-11, Class 3, or No. 1047-12-12 1/2, Grade 125, Class 3.

3. **Lawn fence** shall be the type shown on the plans, a similar type that will match the existing fence, or a type desired by the landowner and approved by the Engineer.

4. **Wood post and braces:**

- a. **Species of wood:** Posts and braces for standard fence shall be Southern pine, Ponderosa pine, Douglas fir, Western hemlock, larch, or white or red cedar as defined in AASHTO M168. Locust may be used for woven wire farm fence and barbed wire fence.
- b. **Cutting requirements:** Round or square posts and braces shall be cut from live growing trees.
- c. **Seasoning:** Posts and braces shall be sufficiently air seasoned in an approved manner for a suitable length of time under favorable climate conditions or otherwise conditioned as part of the treating process to permit adequate penetration of preservative without damage to the wood.
- d. **Peeling:** Posts and braces shall have the inner bark removed to the extent defined by the Southern Pine Inspection Bureau. Knots and projections shall be cut or shaved smooth and flush with the surrounding surface of the unit.
- e. **End finish:** Butt ends of posts shall be sawn square.
- f. **Dimensions:** Posts shall not vary from the length specified on the plans by more than 1 inch. Thickness dimensions shall be undressed dimensions and shall not vary from the dimensions shown on the plans by more than 1/4 inch.
- g. **Straightness:** Wood posts and braces shall be free from bends in more than one place and free from short or reverse bends. The straightness of the post or brace shall be such that a straight line from the center of the tip to the center of the butt shall not depart from the center of the post by more than 2 percent of the length.
- h. **Grading for square posts and braces:** Grading shall conform to the requirements of (b)4.a. herein.
- i. **Preservative treatment:** Posts and braces, except cedar and locust, shall be treated with a preservative in accordance with the requirements of Section 236 except that waterborne preservatives shall not be used in the treatment of posts and braces to be erected in marshy areas. Oil-borne preservatives shall not be used where the posts and braces will come into contact with salt water.

Cutting and trimming of the ends shall be performed prior to treatment.

- 5. **Metal posts and braces:** Post anchor plates shall have a surface area of at least 16 square inches. Posts shall be in accordance with the following:
 - a. **Steel posts and braces** shall be galvanized and shall conform to the requirements of Section 233.
 - b. **Galvanized pipe** shall conform to the requirements of (a)5.d. herein.
- 6. **Gates** similar in type to those that exist may be substituted for gates shown on the plans or standard drawings if preferred by the landowner and approved by the Engineer.

7. **Brace wire** shall be 9 gage and shall conform to the requirements of AASHTO M279, No. 9, Grade 60, Class 3.

(c) **Temporary Silt Fences, Geotextile Fabric, Silt Barriers, and Filter Barriers:**

1. **Geotextile fabric** shall conform to the requirements of Section 245.
2. **Posts for temporary silt fences** shall be a nominal 2 1/2 by 2 1/2 inch or 3 inch diameter No. 2 Southern pine, a nominal 2 by 2 inch oak, or steel having a weight of at least 1.25 pounds per linear foot and a length of at least 5 feet.
3. **Supports for temporary filter barriers** shall be a nominal 1 by 2 inch or 1 1/2 inch diameter No. 2 Southern Pine or oak or steel having a weight of at least 1.00 pound per linear foot and a length of at least 2.5 feet.

SECTION 243—EPOXY-RESIN SYSTEMS

243.01—Description

These specifications cover epoxy-resin systems to be used for all applications requiring bonding of various materials or as patching or overlay of concrete slabs.

243.02—Detail Requirements

Epoxy-resin materials shall conform to the applicable requirements of Table II-19 and Table II-21.

TABLE II-19
Requirements: Component A

Type Property	EP-3B Max.	EP-3T Max.	EP-4 Max.	EP-5 Max.	EP-6 Max.
Epoxide equivalent	245	220	225	270	245

(a) **Epoxy Systems:**

1. **Types EP-3B and EP-3T** shall be 100 percent reactive high-build coatings designed as a two-coat (minimum) system for protection of concrete exposed to splash zones and tidal water. Type EP-3B shall be the prime or base coat, and Type EP-3T shall be the finish or topcoat.
2. **Types EP-4, EP-5, and EP-6** shall be moisture-insensitive systems designed for structural bonding, sealing, and grouting of dry, damp, or wet structural material free from standing water. Mortar shall be prepared by mixing 3 1/4 parts by volume of loose oven-dried sand to 1 part of premixed Type EP-4 or EP-5 epoxy; however, Type EP-6 shall be mixed on a 1:1 ratio.

Mortars shall be mixed to a uniform consistency.

TABLE II-21
Requirements: Mixed Epoxy Systems

Property	EP-3B Red		EP-3T Gray		EP-4 Straw		EP-5 ¹ Straw		EP-6 Lt. Straw		CTE Black	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Pot life at 75°F	40	65	40	65	35	55	35	35	20	30	20	40
Tensile strength (psi) at 75°F	-	-	-	-	3,000	-	2,000	-	1,500	-	400	-
Tensile elongation (%) at 75°F	-	-	-	-	1	3	5	15	5	15	30	-
Water absorption (Max. %)	-	0.8	-	0.8	-	0.8	-	0.8	-	0.8	-	0.8
2-in Cubes, compressive strength (psi, 24 hr, dry) (min.)	-	-	-	-	6,000	-	-	-	-	-	-	-
Strength (psi, 48 hr, wet) (min.)	-	-	-	-	7,000	4,000	4,000	-	4,000	-	-	-
Bond strength: (7 day) Hardened concrete to hardened concrete or fresh concrete (psi min.)	3,000	3,000	3,000	3,000	3,000	-	3,000	-	3,000	2,500	-	-
Ash content (%)	20	30	10	20	-	0.5	-	0.5	5	15	-	5.0
Viscosity												
Poises	40	100	40	150	20	40	10	25	-	-	-	-
Spindle No.	4	4	3	3	3	3	3	3	Gel	-	-	-
Speed	10 or 20	10 or 20	20	20	20	20	20	20	-	-	-	-
Volatile content (max. %)			6.0	3.0	3.0	3.0	3.0	3.0	3.0	20.0	-	-

¹Epoxy system EP-5LV shall have the same requirements as epoxy system EP-5 except that the viscosity shall be less than 9.0 poises.

Type EP-4 shall be a high-modulus, rigid, general purpose adhesive with a tensile elongation of 1 to 3 percent. Type EP-4, low viscosity, shall be used to seal rigid cracks.

Type EP-5 shall be a low-modulus patching, sealing, and overlay adhesive with an elongation of at least 10 percent. When used as a penetrating sealer and to repair nonrigid cracks, Type EP-5 shall be of a low viscosity.

Type EP-6 shall be a low-modulus, nonsagging, flexible adhesive with an elongation of at least 5 percent. Type EP-6 shall be used for bonding or repairing damp and under-water surfaces where a nonsagging, low-modulus material is required.

- (b) **Classes:** Epoxy resin shall be formulated for use at specific temperatures. Three classes of systems are defined according to the range of temperatures for which they are suited. The controlling temperature shall be that of the surface of the hardened concrete to which the bonding system is applied.

Where unusual curing rates are desired and upon the approval of the Engineer, a class of bonding agent may be used at a temperature other than that for which it is normally intended. The class and gel temperature shall be as follows:

1. **Class A:** for use with ambient air and surface temperatures less than 40 degrees F
2. **Class B:** for use with ambient air and surface temperatures greater than or equal to 40 degrees F and less than or equal to 60 degrees F
3. **Class C:** for use with ambient air and surface temperatures greater than 60 degrees F

- (c) **Mixing Epoxy:** Epoxy resin shall be furnished in two components for combining in accordance with the manufacturer's instructions immediately prior to use. Component A shall contain a condensation product of epichlorohydrin with bisphenol A and shall conform to the requirements specified in Table II-19. Component B shall contain one or more hardening agents that when mixed with Component A will cause the system to polymerize and harden to conform to the requirements specified in Table II-21. If the mixture proportion of Component A to Component B exceeds 2:1, only complete units as packaged by the manufacturer shall be used.

Contents of the separate packages containing Component A and Component B shall be thoroughly stirred prior to use. The same paddle shall not be used to stir Component A that is used to stir Component B. The Contractor shall dispose of solvents used for cleaning in accordance with applicable policies and procedures of the Virginia Department of Waste Management. Components A and B shall be stored between 65 degrees F and 80 degrees F for at least 2 hours before use. Epoxy components may be heated in hot water or by indirect heat prior to mixing to bring them to the required temperature. Solvents and thinners shall not be used except for cleaning equipment.

Mixing of epoxy components shall be in accordance with the manufacturer's instructions.

When mineral fillers are specified, they shall be inert and nonsettling or readily dispersible. Materials showing a permanent increase in viscosity or the settling of pigments that cannot

TABLE II-22
Fine Aggregate (Silica Sand)

Amounts Finer Than Each Laboratory Sieve (Sieve Opening) (% by Weight)						
Grading	No. 8	No.16	No. 20	No. 30	No. 40	No. 100
D	Min 100	30-70		Max 5		Max 1
E	Min 100	99 ± 1	95 ± 5		Max 10	

Grading D aggregate shall be used in Class I waterproofing and other skid-resistant applications. Grading E aggregate shall be used in epoxy patching mortars and loop detector sealants. Aggregates shall be oven dried.

be readily dispersed with a paddle shall be replaced at the Contractor's expense. At least 95 percent of the filler shall pass the No. 300 sieve.

- (d) **Aggregates:** Aggregate for surface application work shall be nonfriable, nonpolishing, clean, and free from surface moisture. Silica sand having a well-rounded particle shape shall be used. Aggregates that will be exposed to traffic shall have a Mohs scale hardness of at least 7. In surface applications, the aggregate shall be applied on the epoxy surface in excess of the amount necessary to cover the surface, shall be sprinkled or dropped vertically in such a manner that the level of epoxy mixture is not disturbed, and shall be applied within 5 minutes after application of the epoxy. At temperatures below 70 degrees F, a maximum of 10 minutes will be allowed. The grading analysis of the fine aggregate (silica sand) shall conform to the requirements of Table II-22.

243.03—Handling and Storing Materials

The two components of the epoxy-resin system shall be furnished in separate containers that are non-reactive with the materials. The size of the containers shall be such that the recommended proportions of the final mixture can be obtained by combining one container of Component A with one container of Component B. The size of the container shall be not more than 10 gallons. When less than one complete unit is used, each component shall be measured within ± 2 percent of the volume required. Batches of less than 6 fluid ounces shall be measured within ± 1 percent.

Containers shall be identified as "Component A—Contains Epoxy Resin" and "Component B—Contains Hardener" and shall show the type, class, and mixing directions. Each container shall be marked with the name of the manufacturer; class, batch, or lot number; date of packaging; date of shelf life expiration; pigmentation, if any; and the quantity contained in pounds and gallons.

243.04—Acceptance

Shipments of less than 15 gallons may be accepted upon certification. The Contractor shall submit a certification from the manufacturer that Components A and B conform to these specifications. The certification shall consist of a statement by the manufacturer that Components A and B have been sampled and tested. The certification shall be signed by an authorized agent of the manufacturer and contain actual results of tests performed in accordance with the methods specified herein.

For shipments of 15 gallons or more, at least one random test sample of each component from each batch or lot number will be taken by the Department. The quantity of Component A required to react

243.04

with 1 quart of Component B will be a sufficient sample for the tests specified. Components shall be furnished in as few different batches or lots as possible.

Tests will be performed in accordance with the following methods:

Characteristics	Test Method
Viscosity	VTM-115, Model DV-II Brookfield Viscometer VTM-115 test conditions: Determinations to be made at: Class A, 32°F Class B, 50°F Class C, 77°F
Epoxide equivalent	ASTM D1652
Volatile content	ASTM D1259, Method B, for mixed system ASTM D1259 test conditions: Sample cured 4 days at room temperature and weighed on previously weighed metal foil.
Filler content	AASHTO T-111, on Component A
Ash content	ASTM D482
Pot life	AASHTO T237 AASHTO T237 test conditions: Determinations to be made at: Class A, 32°F Class B, 50°F Class C, 75°F
Tensile strength	ASTM D638
Bond strength	VTM-41
Compressive strength	VTM-41
Water absorption	ASTM D570
Thermal shear	VTM-42

SECTION 244—ROADSIDE DEVELOPMENT MATERIALS

244.01—Description

These specifications cover the various materials, such as fertilizers, seeds, plants, sod, and mulch, for use in landscaping and materials used for soil retention to help prevent erosion.

244.02—Detail Requirements

- (a) **Herbicides:** Herbicides shall be registered with the Virginia Department of Agriculture and Consumer Services in accordance with the Virginia Pesticide Law and shall be supplied in the manufacturer's containers clearly labeled as to the composition, brand, and name and address of the manufacturer.

1. **Herbicide for control of broadleaf weeds** shall contain at least 3 pounds of 2,4-D as an oil-soluble, water-emulsifiable amine salt. It shall have a shelf life of at least 2 years and shall be homogeneous with slight agitation. The type of amine salt and the actual acid equivalent per gallon shall be shown on the container.
2. **Herbicide for stump treatment** shall be dicamba CST and shall be applied in accordance with the manufacturer's registered label.

(b) **Topsoil:**

1. **Class A topsoil:** Class A topsoil shall be stockpiled topsoil that has been salvaged in accordance with the requirements of Section 303.04(a). It shall be the original layer of the soil profile formed under natural conditions, technically defined as the "A" horizon or as defined by the United States Department of Agriculture–Natural Resources Conservation Service (USDA–NRCS) Soil Survey Division. It shall be free from refuse and any other materials toxic to plant growth and subsoil, stumps, viable noxious weeds, roots, brush, rocks, clay lumps, or similar objects larger than 3 inches in any dimension.
2. **Class B topsoil:** Class B topsoil shall be topsoil furnished from sources outside the project limits and shall be the original top layer of a soil profile formed under natural conditions, technically defined as the "A" horizon or as defined by USDA–NRCS Soil Survey Division. It shall consist of natural, friable, loamy soil without admixtures of subsoil or other foreign materials and shall be free of viable noxious weed seed, plant propagules, brush, rocks or other litter, and rocks greater than 3 inches in any dimension. It shall have demonstrated by evidence of healthy vegetation growing or having grown on it prior to stripping that it is well drained and does not contain substances toxic to plants. The Contractor shall submit a source of materials for topsoil on the project prior to use. The Department reserves the right to reject any topsoil material not complying with the requirements of this specification.

The allowable pH range for Class B topsoil for use in establishing sod or turf shall be 5.5 to 7.0.

Class B topsoil shall be a "sandy loam," "loamy sand," or "sandy clay loam" soil as defined by the USDA Soil Textural Classification System with an organic matter content between 1 and 8 percent or as approved in writing by the Engineer.

3. **Testing and documentation:** The Contractor shall submit the following test reports to the Engineer for Class B topsoil prior to use. Testing shall be completed by an independent commercial soils testing laboratory:
 - a) **Soil analysis** of topsoil including pH factor, mechanical analysis (composition), salinity, percentage of organic content, and soil classification based thereon.
 - b) **Recommendations** on type and quantity of additives required to establish a satisfactory pH and bring the supply of nutrients to a level satisfactory for sustaining turf and/or for use as a soil mix for planting if applicable.
- (c) **Seeds:** Kinds and varieties of seeds shall be delivered to the project in separate sacks bearing a green seed label denoting that the seed was inspected and approved by the Virginia

Crop Improvement Association. Open bags will not be accepted for use. Seeds shall be mixed under the observation of the Engineer on the project or at other approved locations. Seeds shall comply with applicable state and federal seed laws and contract requirements. Seed shall not be used until approved by the Engineer.

Seed shall be subject to inspection by Virginia State Seed Regulatory Inspectors of the Virginia Department of Agriculture and Consumer Services.

Seed tests shall be completed within the 9-month period prior to the beginning of the area scheduled seeding period during which the seed is to be used.

Seed shall not be or have been stored in an enclosure where herbicides, kerosene, or other material detrimental to seed germination is stored.

Noxious weed seeds, as defined by the rules and regulations adopted for enforcement of the Virginia Seed Law, will not be permitted. The number of restricted noxious weed seeds shall be not more than the number per ounce or per pound of noxious weed seeds specified in the rules and regulations of the Virginia Seed Law.

The tag from each sack of seed shall be signed by the Contractor and delivered to the Engineer after each sack is completely used.

- (d) **Fertilizers:** Fertilizer shall be uniform in composition, free flowing, and suitable for application with approved equipment. The fertilizer shall be delivered to the project in bags or other convenient containers, each fully labeled, and shall conform to all applicable state and federal laws and regulations. Additional nutrients shall be added only when specified in the contract documents or in accordance with the provisions of Section 109.05. Fertilizer shall be subject to testing by the Virginia Department of Agriculture and Consumer Services. The Department reserves the right to reject fertilizer materials that do not comply with the requirements of these specifications or to be compensated in an amount as decided by the Engineer for failure of complying with the requirements of the Virginia Fertilizer Law. Other fertilizer products and rates may be substituted with the prior written approval from the Engineer.

A copy of the material safety data sheet (MSDS) shall be provided to the Department for each type of fertilizer supplied with each fertilizer delivery. Any fertilizer delivery that is not accompanied by the appropriate MSDS will be rejected.

1. **Fertilizer for seeding, sodding, sprigging, and plugging** shall have a guaranteed 1-2-1 ratio and a nitrogen, phosphorous, and potassium (NPK) analysis as detailed in the plans with a minimum 30 percent of the nitrogen from a slow release or slowly soluble source with the remainder of the nitrogen from urea or ammonium nitrate. The following types of slow release or slowly soluble nitrogen fertilizers may be used: urea formaldehyde (UF) (ureaform, methylene urea, and methylene diurea/dimethylene triurea); isobutylidene diurea (IBDU); sulfur-coated urea (SCU); and polycoated urea (PCU). UF products shall have a minimum activity index of 40 percent. The IBDU minimum size guide number shall be 230. All UF and IBDU products shall indicate the slow release/slowly available nitrogen source on the fertilizer analysis label as water-insoluble nitrogen. PCU and SCU shall have a minimum 3-month release duration for the total product. The phosphorous content of the fertilizer shall be triple superphosphate or diammonium phosphate. The potassium content of the fertilizer shall be potassium

chloride, commonly known as muriate of potash. Slow release or slowly soluble fertilizers may be applied with a hydraulic seeder except for SCU. Fertilizer shall be applied in accordance with the requirements of Section 603.

2. **Fertilizer for planting plants** shall have a guaranteed 1-2-1 ratio and a 15-30-15 analysis with a minimum of 40 to 50 percent of the nitrogen from one of the following slow release or slowly soluble sources, with the remainder of the nitrogen from urea or ammonium nitrate: soluble UF, SCU, and PCU. The UF products shall have a minimum activity index of 40 percent. SCU and PCU shall have a minimum 3-month release duration for the total product. Slow release or slowly soluble fertilizers shall be applied as a dry surface application as shown in the Department's *Road and Bridge Standards*, Volume II, Landscape Section.
- (e) **Lime:** Lime shall be agricultural grade ground limestone. Agricultural grade pulverized or pelletized lime products may be substituted at no additional cost to the Department.

The material source shall be registered with and approved by the Virginia Department of Agriculture and Consumer Services in accordance with the Virginia Agricultural Lime Law and shall conform to the requirements of Section 240. All lime shall be subject to testing by the Virginia Department of Agriculture and Consumer Services. Other lime products may be substituted with approval from the Engineer.

- (f) **Inoculating Bacteria for Treating Leguminous Seeds:** Bacteria shall be a pure culture of nitrogen-fixing bacteria selected for maximum vitality. Cultures shall be not more than 1 year old and shall be subject to the approval of the Engineer.
- (g) **Mulch:** Mulch shall conform to the following unless otherwise approved in writing by the Engineer:
1. **Mulch for seeding** (vegetative) shall consist of dry straw or hay, free from noxious weeds. Mulch shall be reasonably bright in color and shall not be musty, moldy, caked, decayed, or dusty.
 2. **Wood cellulose fiber mulch for hydraulic seeding** shall consist of specially prepared wood cellulose processed into a uniform fibrous physical state. Mulch shall be dyed green or contain a green dye in the package that will provide an appropriate color to facilitate visual inspection of the uniformly spread slurry. Mulch, including dye, shall not contain germination-inhibiting or growth-inhibiting factors. Mulch shall be manufactured and processed so that it will remain in uniform suspension in water under agitation and will blend with seed, fertilizer, and other additives to form a homogeneous slurry. Mulch shall form a blotterlike ground cover, on application, having moisture absorption and percolation properties and shall cover and hold grass seed in contact with the soil without inhibiting the growth of grass seedlings. Field and equipment performance determinations by the Department shall be prerequisites for the approval of a source of supply for mulch.

The manufacturer shall provide certification that the mulch conforms to the following:

Property	Value
Fiber or particle size	
Length	To approximately 0.39 inch (10 mm)
Thickness or diameter	Approximately 0.04 inch (1 mm)
Net dry weight content (VTM-47)	Minimum stated on bag
pH range (TAPPI T509 or ASTM D 778)	4.0 to 8.5
Ash content (TAPPI T413 or ASTM D 586)	Maximum 7.0%
Water-holding capacity (VTM-46)	Minimum 90%

Mulch shall not contain elements or compounds at concentration levels that will be phytotoxic.

In addition to making field performance determinations, the Department may sample and perform such other tests on mulch to ensure that it conforms to these specifications. Only those materials that have been evaluated by the Department and that appear on its list of approved sources of supply will be accepted.

Mulch shall be delivered in packages of uniform weight bearing the name of the manufacturer, the net weight, and an additional statement of the net dry weight content.

3. **Wood chips** processed from clearing and grubbing operations may be used for mulch on seeded areas as directed by the Engineer. Wood chips shall be not more than 3/8 inch in thickness or 6 square inches in area.
 4. **Mulch for individual planting pits and planting beds** shall be double-shredded hardwood mulch aged for at least 1 year and brown in color. A representative sample shall be submitted to the Engineer for approval prior to delivery to the work site.
- (h) **Sod:** Sod shall be cultivated material conforming to the requirements of the State Board of Agriculture for state-approved sod or the State Sod Certification Agency for state-certified sod. Root development shall be such that standard size pads will support their own weight and retain their size and shape when suspended vertically from a firm grasp on the uppermost 10 percent of the area. The top growth of sod shall be mowed so that the height of the grass will be 2 to 3 inches at the time of the stripping operation. Sod may be furnished in any standard pad width and length provided the dimensions do not vary from the average by more than 5 percent. Sod shall be machine stripped at a uniform soil thickness of at least 1 inch. Broken, torn, or irregularly shaped pads will be rejected.
- (i) **Trees, Shrubs, Vines, and Other Plants:** The botanical and common name of plants shall be in accordance with the latest edition of *Standardized Plant Names*, prepared by the Editorial Committee of the American Joint Committee on Horticultural Nomenclature in effect on the date of the Notice of Advertisement.
1. **Quality and size:** Plants shall conform to the requirements of the current *American Standard for Nursery Stock* (ANSI Z-60.1) by the American Nursery and Landscape Association and these specifications.

Plants shall be representative of their normal species and varieties; shall have well-furnished branch systems and vigorous fibrous root systems characteristic of their respec-

tive kinds; shall be grown in a state-approved, certified nursery; and shall bear evidence of proper nursery care, including adequate transplanting and root pruning. Plants shall comply with state and federal laws governing inspection for plant diseases and insect infestation and shall be free from insect pests, plant diseases, disfiguring knots, stubs, sunscald, bark abrasions, or any other form of damage or objectionable disfigurements.

When a minimum and maximum size or range is specified, an average size shall be furnished. Plants shall not be pruned before delivery or cut back from larger sizes to conform to the sizes specified. Sizes furnished shall be those specified at the time of delivery and before the usual pruning at the time of planting. Nursery-grown trees shall be free from cuts of limbs that are not healed and cuts more than 3/4 inch that have not completely callused over. Plants from cold storage will not be accepted. Deciduous plants, except those grown in containers, shall be dormant when planted.

2. **Digging and protection:** Digging shall be in accordance with the current *American Standards for Nursery Stock* and done in a manner that will avoid damage to or loss of roots, but roots that are cut shall be cleanly cut. Balled and burlapped plants shall be properly dug and protected to preserve the natural earth in contact with the roots. Manufactured balls or processed balls will not be accepted. Balls shall be firmly wrapped and tied with approved materials. Balled plants will not be accepted if the ball is broken, cracked, or loose. After plants are dug, their roots shall be protected from damage. Roots of bare root plants shall be kept moist at all times. Bare root plants shall be further protected by wrapping in wet straw, moss, burlap, or other approved material.
3. **Plantable pots:** In lieu of using burlap with balled plants, plants may be dug as specified herein and placed in plantable pots. Pots shall be constructed of organic, biodegradable material that will readily decompose in soil and shall not be smaller in any dimension than the size specified for balled and burlapped root systems. At the time of planting, the lip or rim of pots shall be broken away, and drainage holes shall be provided as directed. Plants with balls that have been grown in pots or with loose stems will be rejected.
4. **Container-grown plants:** In addition to the requirements of the *American National Standard for Nursery Stock*, container-grown plants shall conform to the following:
 - a. 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.
 - b. Encircling roots shall not have grown in such a manner that they will cause girdling of the trunk or stems.
 - c. Roots shall have been grown in the soil medium for a minimum of 6 months extending to the limits of the container on all sides and from top to bottom.
5. **Collected plants:** Collected plants from wild or native stands shall not be used without the written permission of the Engineer unless specified on the plans. Wild or native plants shall be clean, sound stock and free from injury, and the quality of the plants shall be similar to that specified for nursery-grown material. Stock shall have sufficient

root systems to ensure successful transplanting. Balls, when specified, shall be tight and well formed.

6. **Clumps:** Clumps shall be dug from good soil that has produced a fibrous root system typical of the nature of the plant and shall have earth and incidental vegetation adhering to roots.

(j) **Miscellaneous Planting Materials:**

1. **Twine** for wrapping balled and burlapped trees shall be made of an organic material, biodegradable twine, at least two-ply.
2. **Composted yard waste** shall be dark brown or black in color and consist of decomposed leaves, branches, and grass clippings. Prior to delivery, the Contractor shall submit to the Engineer for approval, a sample of the composted yard waste and a test report from an independent laboratory verifying that the material conforms to the following analysis:
 - pH = 5.5 dry–8.0 wet
 - Moisture Content = 35%–45%
 - Particle Size = Pass through a 1-inch screen or smaller
 - Stability = Stable to highly stable, thereby providing nutrients for plant growth
 - Maturity/Growth Screening = Aged (cured) for a minimum of 6 months, reach thermophilic (113–158 degrees F) temperature ranges following a minimum of two successive turnings of the compost, and pass maturity tests or demonstrate its ability to enhance plant growth
 - Soluble Salt Concentration = 3.0 dS/m (mmhos/cm) or less
 - Nutrient Content: Nitrogen = 0.5%–3.5%
 - Phosphorous = 0.2–4.0%
 - Potassium = 0.3%–2.0%
 - Density = Not more than 1,250 pounds per cubic yard.

The Contractor shall submit the following information to the Engineer 30 days prior to the date the compost is shipped to the construction site:

- a. A vendor’s certificate or affidavit attesting that the “Composted Yard Waste” complies with the requirements of this specification.
- b. A test report from an independent certified laboratory verifying that the material complies with the requirements for use as specified by the Virginia Department of Environmental Quality and United States Environmental Protection Agency/40

CFR Part 503 Regulations February 1993 with regard to heavy metal content and restrictive use of biosolids.

- c. A 2-gallon sample of the material for visual inspection. In addition, the test report shall indicate that the compost material is free of viable weed seed, plant propagules, and harmful pathogens. Non-organic materials such as concrete, plastic, metal, glass, paper products, chemically treated plywood, plywood, pressboard, and organic pine by-products will not be accepted. The Engineer reserves the right at any time to test and reject compost material that does not comply with the requirements of this specification. Other compost products may be substituted with the written approval of the Engineer.
3. **Horticultural Grade Perlite** shall be a fine-to-medium grade, non-organic volcanic mineral identified as Perl-Lome having closed air cells and surface cavities, expanded to form a granular, snow-white material, 5 to 20 times its original volume. Perlite shall have a weight of 5 to 8 pounds per cubic foot. Prior to delivery, the Contractor shall submit to the Engineer for approval, a sample of the perlite and a manufacturer's test report or product certification verifying that the material complies with the following analysis and gradation:

pH = 6.5 to 7.5

Nutrient Content = Sterile.

Standard Sieve or Micron Size	Perlite Gradation	
	Fine	Medium
+16 mesh	10% maximum	60% maximum
+100 mesh	60% minimum	85% minimum

4. **Burlap used for wrapping the tree ball** shall be made of an organic biodegradable material.
5. **Water** used in watering plants shall be obtained from fresh water sources and shall be free from chemicals and other toxic substances harmful to plants. Brackish water shall not be used. The source of water will be subject to the approval of the Engineer.
6. **Staking and guying materials** shall be 14-gage galvanized steel wire. Hose shall be corded rubber, 1/2 inch or 3/4 inch, and solid green in color. Turnbuckles shall be galvanized steel or zinc-coated steel. Stakes for anchoring trees and shrubs shall be 2 inch by 2 inch rough dressed hardwood in the appropriate length and reasonably free of knots. Trees and shrubs shall be anchored in accordance with Section 1200 of the Department's *Road and Bridge Standards* unless otherwise indicated on the plans. Other staking, guying, and anchoring methods and materials specifically designed for securing trees and shrubs may be substituted with prior approval in writing from the Engineer or as designated on the plans.
7. **Below-ground tree anchors** shall be below-grade steel stabilizers capable of fixing the root ball in place until the tree has established itself in place. Prior to ordering material, the Contractor shall furnish the Engineer manufacturer's product data for the type of anchoring system he proposes to supply for review.

8. **Tree protection tubes** shall be constructed from flexible UV-inhibited polyethylene, polypropylene, or similar material designed to speed photosynthesis, promote seedling growth, and reduce planting stress by trapping moisture, thereby raising relative humidity and ambient temperature inside the tube. Tree tubes shall protect the tree seedlings from animals, wind desiccation, small rodents, chemical sprays, and insects. The design of the tree tubes shall not be detrimental to the establishment and growth of the seedling or young tree. Tree tube designs shall be capable of accommodating tree growth for at least 3 years after planting.

(k) **Soil Retention Coverings:**

1. **Jute mesh** shall be a uniform, open, plain weave of undyed and unbleached single layer jute yarn. The yarn shall be loosely twisted and shall not vary in thickness by more than its normal diameter. Jute mesh shall be new, and its length shall be marked on each roll.

Between strands lengthwise, openings shall be 0.60 inch \pm 25 percent. Between strands crosswise, openings shall be 0.90 inch \pm 25 percent. Jute mesh shall weigh 0.9 pound per square yard \pm 5 percent.

2. **Soil retention mats** shall consist of a machine-produced mat of wood fibers, wood excelsior, or manmade fiber that shall intertwine or interlock. Matting shall be nontoxic to vegetation and germination of seed and shall not be injurious to the unprotected skin of the human body.

Mats shall be of consistent thickness, with fiber evenly distributed over its entire area, and covered on the top and bottom side with netting having a high web strength or covered on the top side with netting having a high web strength and machine sewn on 2-inch centers along the longitudinal axis of the material. Netting shall be entwined with the mat for maximum strength and ease of handling.

3. **Soil stabilization mats** shall be from the Department's approved products list for the site conditional use(s) specified.

- (l) **Fencing and Steel Posts for Protection of Landscape:** When specified on the plans, fencing to delineate areas of landscaping to be protected shall be 40 inches in height, international orange, high-visibility, plastic (polyethylene) web fencing. Fence posts shall be conventional metal "T" or "U" posts 6 feet in length. The plastic fencing shall be securely fastened to the posts in a manner approved by the Engineer. The plastic fencing shall have the following physical qualities:

Tensile Yield = Average 2,000 pounds per 4-foot width (ASTM D 638)

Ultimate Tensile Yield = Average 2,900 pounds per 4-foot width (ASTM D 638)

Elongation at Break (%) = Greater than 1000% (ASTM D 638)

Chemical Resistance = Inert to most chemicals and acids.

Other fencing materials may be specified for use in accordance with the requirements of Section 507 or as noted on the plans and specifications or as approved by the Engineer.

SECTION 245—GEOSYNTHETICS

245.01—Description

These specifications cover artificial fiber textile products to be used in transportation construction work.

245.02—Detail Requirements

Geosynthetics shall include a label that clearly shows the manufacturer or supplier name, style name, and roll number. The shipping document shall include documentation to comply with the requirements of Section 245.03.

Each geosynthetic roll shall be wrapped or otherwise packaged in a manner that will protect the geosynthetic, including the ends of the roll, from damage due to shipment, water, sunlight, and contaminants. The protective wrapping shall be maintained during periods of shipment and storage.

During storage, geosynthetics rolls shall be elevated off the ground and adequately covered to protect them from the following: site construction damage; precipitation; extended ultraviolet radiation including sunlight; chemicals that are strong acids or strong bases; flames including welding sparks; temperatures in excess of 160 degrees F; and other environmental conditions that may damage the physical property values of the geosynthetic. Geosynthetics that are not properly protected may be subject to rejection.

245.03—Testing and Documentation

Each geosynthetic material provided to the project shall be tested by the Contractor to determine conformance with the material properties specified herein within 24 months of submission. Test results reported from AASHTO's National Transportation Product Evaluation Program—Laboratory Results of Evaluations on Geotextile and Geosynthetics may be used. The Contractor shall provide certification of the material in accordance with the requirements of AASHTO M288, Section 4, Certification, and copies of the test results. The Contractor's testing, however, will not be the sole basis for acceptance.

The Department will sample and test the geosynthetics for acceptance to verify conformance with this specification. Sampling shall be performed in accordance with the requirements of ASTM D4354, Procedure C. In the absence of the Department's testing, acceptance may be based on the manufacturer's certifications as a result of testing by the manufacturer of quality assurance samples obtained using the procedure for ASTM D4354 Procedure B Sampling for Manufacturer's Quality Assurance (MQA) Testing. A lot size shall be considered to be the shipment quantity of the given product or a truckload of the given product, whichever is smaller.

Property values, with the exception of apparent opening size (AOS) and panel vertical strain, in these specifications represent minimum average roll values (MARV) in the weakest principal direction (i.e., average test results of any roll in a lot sampled for conformance or quality assurance testing shall meet or exceed the minimum values provided herein). Values for AOS and panel vertical strain represent maximum average roll values.

Tests shall be performed in accordance with the methods referenced in this specification for the indicated application. The number of specimens to test per sample is specified by each test method. Geotextile product acceptance shall be based on conformance to the requirements of ASTM D4759. Product acceptance is determined by comparing the average test results of specimens in a given sample to the specification MARV.

- (a) **Geotextile Fabric for Use in Silt Fences, Silt Barriers, or Filter Barriers:** Geotextile shall function as a vertical; permeable interceptor designed to remove suspended soil from overland water flow. Fabric shall filter and retain soil particles from sediment-laden water to prevent eroding soil from being transported off the construction site by water runoff. Fabric shall contain ultraviolet inhibitors and stabilizers to provide at least 6 months of expected, usable construction life at a temperature of 0 degrees F to 125 degrees F. The tensile strength of the material after 6 months of installation shall be at least 50 percent of the initial strength.

Physical Property	Test Method	Requirements
Filtering efficiency	VTM-51	Min. 75%
Flow rate	VTM-51	Min. 0.2 gal/ft ² /min

In addition to these requirements, the geotextile shall comply with the requirements of AASHTO M288 for temporary silt fence property requirements, Table 6, for grab strength and ultraviolet stability.

- (b) **Geotextile for Use as Riprap Bedding Material:** Geotextile shall comply with the requirements of AASHTO M288 for separation geotextile properties, Table 3, for apparent opening size and ultraviolet stability and geotextile strength property requirements, Table 1, Class 2, for grab strength and puncture strength.
- (c) **Geotextile Fabric for Use in Drainage Systems (Drainage Fabric):** Drainage fabric shall be nonwoven and clog resistant, suitable for subsurface application, and thermally and biologically stable.

The geotextile shall retain at least 75 percent of its ultimate strength when subjected to substances having a pH of a minimum of 3 and a maximum of 12 for a period of 24 hours.

Physical Property	Test Method	Requirements
Permittivity	ASTM D4491	Min. 0.5 sec ⁻¹
Apparent opening size	ASTM D4751	Max. No. 50 sieve

In addition to these requirements, the geotextile shall comply with the requirements of AASHTO M288 for strength requirements, Table 1, Class 3, for grab strength.

- (d) **Geotextile for Use in Stabilization:** These are geotextiles used in saturated and/or unstable conditions to provide the functions of separation and reinforcement.

1. **Subgrade Stabilization Fabric:**

Physical Property	Test Method	Requirements
Apparent opening size	ASTM D 4751	Max. No. 20 sieve

In addition to this requirement, the geotextile shall comply with the requirements of AASHTO M 288 for strength property requirements, Table 1, Class 3, for grab strength, tear strength, and puncture strength.

2. **Embankment Stabilization Fabric Up to 6 Feet High:**

Physical Property	Test Method	Requirements
Apparent opening size	ASTM D 4751	Max. No. 20 sieve
Seam strength	ASTM D 4632	90% specified grab strength

In addition to this requirement, the geotextile shall comply with the requirements of AASHTO M288 for strength property requirements, Table 1, Class 1 for grab strength, tear strength, and puncture strength.

- (e) **Prefabricated Geocomposite Pavement Underdrain:** Prefabricated geocomposite pavement underdrain shall consist of a polymeric drainage core encased in a nonwoven filter fabric envelope having sufficient flexibility to withstand bending and handling without damage. Prefabricated geocomposite pavement underdrain shall conform to the following:

1. **Core:** The drainage core shall be made from an inert, polymeric material resistant to commonly encountered chemicals and substances in the pavement environment and shall have a thickness of not less than 3/4 inch.

Physical Property	Test Method	Requirements
Compressive strength panel vertical strain and core area change	ASTM D1621/D2412	Min. 40 psi at 20% deflection
Panel vertical strain and core area change at 22.7 psi	ASTM D6244	Max. 10% for core area and panel height
Water flow rate) after 100 hr at 10 psi normal confining pressure gradient of no more than 0.1)	ASTM D4716	Min. 15 gal/min/ft width for 12-in specimen length

The core shall retain at least 75 percent of its ultimate strength when subjected to temperatures of 0 degree F and 125 degrees F, respectively, for a period of 24 hours.

2. **Filter Fabric:** Geotextile shall be bonded to and tightly stretched over the core. Geotextile shall not sag or block the flow channels, shall have a life equivalent to that of the core material, and shall conform to the requirements of (c) herein.

- (f) **Geocomposite Wall Drains:** Geocomposite wall drains may be used as an alternative to porous backfill when permitted by the Engineer. Geocomposite wall drains will not be permitted for use with walls considered critical by the Engineer. Critical walls shall include walls over 15 feet in height and walls supporting bridge abutments or other structures on spread footings.

Prefabricated geocomposite wall drain shall consist of a polymeric drainage core encased in a nonwoven filter fabric envelope having sufficient flexibility to withstand bending and handling without damage. Geocomposite wall drains shall conform to the following:

1. **Core:** The drainage core shall be made from an inert, polymeric material resistant to commonly encountered chemicals and substances in the roadway.

Physical Property	Test Method	Requirements
Compressive strength at 20% deflection	ASTM D1621/D2412	Min. 40 psi
Water flow rate (after 100 hr at 10 psi normal confining pressure and gradient of no more than 0.1)	ASTM D4716	Min. 15 gal/min/ft width (for 12-in specimen length)

The core shall retain at least 75 percent of its ultimate strength when subjected to temperatures of 0 degree F and 125 degrees F for a period of 24 hours.

2. **Filter Fabric:** Geotextile shall be bonded to and tightly stretched over the core. Geotextile shall not sag or block the flow channels, shall have a life equivalent to that of the core material, and shall conform to the requirements of (c) herein.
- (g) **Geomembrane Moisture Barrier:** Geomembrane moisture barrier shall be resistant to biological attack. Geomembrane shall be constructed of PVC, shall have a thickness of 30 mils, and shall conform to the requirements of the PVC Geomembrane Institute 1197 material specification for PVC geomembrane or shall conform to the following requirements:

Physical Property	Test Method	Requirements
Thickness	ASTM D5199	Min. 30 mils
Tensile (1-in strip)	ASTM D882	Min. 130 kip/ft
Tear (Die C)	ASTM D1004	Min. 200 lbf
Puncture	ASTM D4833	Min. 620 lbf

- (h) **Dewatering Bag:** A nonwoven geotextile sewn together to form a bag that can be used in lieu of a de-watering basin for the purpose of filtering out suspended soil particles. The bag shall be capable of accommodating the water flow from the pump without leaking at the spout and seams.

Physical Property	Test Method	Requirements
Grab strength @ Elongation >50%(CRE/Dry)	ASTM D4632	Min. 250 lb (min)
Seam strength	ASTM D4632	90% Specified grab strength
Puncture	ASTM D4833	Min. 150 lb
Mullen burst	ASTM D3786	Min. 450 psi
Flow rate	ASTM D4491	Min. 0.189 ft ³ /sec/ft ² (min)
Permittivity	ASTM D4491	Min. 1.2 sec ⁻¹
UV resistance	ASTM D4355	Min. 70% at 500 hr
AOS	ASTM D4751	Max. 100 sieve

- (i) **Paving Geosynthetics:** Paving geosynthetics shall be used as an interlayer between pavement layers. Specific application of these paving geosynthetics shall be determined by the Engineer.
1. **Geotextile Paving Fabric:** The geotextile shall conform to the requirements of AASHTO M288 Paving Fabric Property Requirements, Section 9.
 2. **Pavement Reinforcing Mat:** The geotextile shall meet the requirements of ASTM D7239 Geosynthetic Paving Mat, Type 1.

SECTION 246—PAVEMENT MARKING

246.01—Description

These specifications cover material for use in the various retroreflective pavement-marking applications.

246.02—Detail Requirements

Materials that must be heated for application shall not exude fumes that are toxic or injurious to persons or property when heated to the application temperature.

Materials shall withstand air and roadway temperature variations from 0 degrees F to 140 degrees F without deforming, bleeding, staining, or discoloring and shall maintain their original dimensions and placement without chipping, spalling, or cracking. Material shall not deteriorate because of contact with sodium chloride, calcium chloride, mild alkalis and acids, or other ice control materials; oil in the pavement material; or oil and gasoline drippings from vehicles.

- (a) **White and Yellow Pavement Marking Material:** White pavement marking material shall be equivalent in color to Federal Standard (FS) Color No. 595-17886, and yellow pavement marking material shall be equivalent in color to FS Color No. 595-33538.

Color determination will be made for markings, and the diffuse daytime color of the markings shall conform to the International Commission on Illumination (CIE) chromaticity coordinate limits that follow. Color determination for liquid marking materials will be made

without drop-on beads at least 24 hours after application. Color determination for thermoplastic will be made in accordance with the requirements of AASHTO T250.

CIE Chromaticity Coordinate Limits (Initial without Drop-on Beads)

Color									Daytime Luminance Factor Y (%)	
	1		2		3		4		Min.	Max.
	x	y	x	y	x	y	x	y		
White (Types A; B, Classes I, II, III, F)	0.355	0.355	0.305	0.305	0.285	0.325	0.335	0.375	80.0	—
Yellow (Types A; B, Classes II, III; F except thermoplastic)	0.493	0.473	0.518	0.464	0.486	0.428	0.469	0.452	50.0	60.0
Yellow (Types B, Class I; Type F if thermoplastic)	0.499	0.466	0.545	0.455	0.518	0.432	0.485	0.454	40.0	60.0

Color readings will be determined in accordance with the requirements of ASTM E1349 using CIE 1931, 2 degrees standard observer and CIE standard Illuminant D65.

The retained daytime color of markings shall conform to the following CIE chromaticity coordinate limits when measured on a beaded marking after a period of 90 days for construction pavement markings and 1 year for all other markings:

CIE Chromaticity Coordinate Limits (Retained)

Color	1		2		3		4	
	x	y	x	y	x	y	x	y
White	0.355	0.355	0.305	0.305	0.285	0.325	0.335	0.375
Yellow	0.560	0.440	0.490	0.510	0.420	0.440	0.460	0.400

Retained color readings will be determined using a 0 degrees/45 degrees Hunter Labminiscan Spectro-Colorimeter or equivalent instrument in accordance with the requirements of ASTM E1349 using CIE 1931, 2 degrees standard observer and CIE standard Illuminant D65.

The initial nighttime color of yellow thermoplastic and yellow epoxy pavement marking material shall conform to the following CIE chromaticity coordinate requirements when tested in accordance with VTM-111:

CIE Chromaticity Coordinate Limits (Initial with Drop-on Beads)

Color	1		2		3		4	
	x	y	x	y	x	y	x	y
Yellow	0.486	0.439	0.520	0.480	0.560	0.440	0.498	0.426

The marking material shall not be formulated with any compounds of the heavy metals listed in 40 CFR 261.24, Table 1, except that barium sulfate is allowed. Total heavy metal levels, with the exception of barium sulfate, shall not exceed 20 times the specified regulatory limits.

The amount and type of yellow pigment and inert filler for yellow material shall be at the discretion of the manufacturer provided the material complies with all other requirements of this specification.

- (b) **Paint Pavement Marking Material (Type A):** Paint material shall be a fast drying water-based, nonleaded, acrylic resin paint suitable for use on both asphalt and hydraulic cement concrete surfaces. Paint shall be selected from the Department's approved products list. Paint products will be included on the Department's approved products list after the Department determines conformance to the specifications on both asphalt and hydraulic cement concrete roadways. Determination of conformance will include, but not be limited to, the evaluation of test data from AASHTO's National Transportation Product Evaluation Program (NTPEP) or other Department-approved facilities.
- Hiding power:** Paint shall show a dry hiding quality that will give a contrast ratio of at least 0.96 at 0.38 mm (15 mil) wet film thickness.
 - Settling properties:** Settling shall be no less than a rating of 8 when tested in accordance with ASTM D869.
 - Freeze-thaw and heat stability:** Paint shall show no coagulation or change in viscosity greater than +/- 5 KU.
 - Water resistance:** Paint shall show no blistering, peeling, wrinkling, softening, or loss of adhesion.
 - VOC:** The VOC content shall be no greater than 150 grams/liter when tested in accordance with EPA Method 24.
 - Flash point:** Paint shall have a flash point of at least 140 degrees F when tested in accordance with the requirements of ASTM D93, Pensky-Martens Closed Cup.
 - No-track time:** Paint shall have a 60-second maximum vehicle no-track time when measured in accordance with the NTPEP Field Test Procedures.
 - Maintained retroreflectivity and durability:** Maintained retroreflectivity and durability shall conform to the following requirements after the material has been installed on the test deck for 1 year:

- a. **Maintained Retroreflectivity:** The photometric quantity to be measured is the coefficient of retroreflected luminance (R_L) in accordance with the requirements of ASTM E1743 for 15-meter geometry and ASTM E1710 for 30-meter geometry. R_L shall be expressed in millicandelas per square foot per foot-candle and shall be at least either 150 for 15-meter or 100 for 30-meter when measured in the skipline or centerline areas.
 - b. **Durability:** Paint shall have a durability rating of at least 4 when determined in the wheel path area.
- (c) **Thermoplastic Pavement Marking Material (Type B, Class I):** Thermoplastic material shall be suitable for use on asphalt concrete surfaces, and yellow thermoplastic material shall be selected from the Department’s approved products list. Yellow thermoplastic products will be included on the approved list after the Department determines their conformance to the specifications. Thermoplastic material shall have the pigment, beads, and filler well dispersed in the resin and shall be free from skins, dirt, and foreign objects.

1. **Composition:**

Component	White	Yellow
	(Percent by Weight)	
Binder	18.0 min.	18.0 min.
Glass beads	25.0 min.	25.0 min.
Titanium dioxide	8.0 min.	—
Calcium carbonate and inert fillers	49.0 max.	—

The binder shall be either alkyd or hydrocarbon. If an alkyd thermoplastic is used, the binder shall consist of synthetic resins, at least one of which is solid at room temperature, and high-boiling plasticizers. At least one-half of the binder composition shall be a maleic-modified glycerol ester of resin and shall be at least 10 percent by weight of the entire material formulation.

2. **Physical requirements:**

- a. **Water absorption:** Materials shall have not more than 0.5 percent retained water by weight when tested in accordance with the requirements of ASTM D570, Procedure A.
- b. **Softening point:** Materials shall have a softening point of at least 194 degrees F as determined in accordance with the requirements of ASTM E28.
- c. **Specific gravity:** The specific gravity of the thermoplastic compound at 77 degrees F shall be from 1.7 to 2.2.
- d. **Impact resistance:** The impact resistance shall be at least 10 inch-pounds at 77 degrees F after the material has been heated for 4 hours at 400 degrees F and cast into bars of 1-inch cross-sectional area, 3 inches long, and placed with 1 inch extending above the vise in a cantilever beam, Izod-type tester conforming to the requirements of ASTM D256 using the 25 inch-pound scale.

- e. **Drying time:** Material shall set to bear traffic in not more than 2 minutes when the road temperature is 50 degrees F or above.
 - f. **Durability and wear resistance:** Material shall be designed to provide a life expectancy of at least 3 years under an average daily traffic count per lane of approximately 9,000 vehicles.
 - g. **Glass beads:** Glass beads shall conform to the requirements of Section 234.
 - h. **Flashpoint:** The material flashpoint shall be no less than 500 degrees F when tested in accordance with the requirements of ASTM D92.
- (d) **Polyester-Resin Pavement Marking Material (Type B, Class II):** Polyester-resin is a two-component pavement marking material suitable for use on hydraulic cement concrete surfaces.

1. **Composition (uncatalyzed material):**

	Min.	Max.
Pigment	36.0	40.0
Acrylic monomer	8.5	—
Polyester resin	—	55.5

2. **Physical requirements (uncatalyzed material):**

- a. **Viscosity:** Viscosity (25 degrees C) determined in accordance with the requirements of ASTM D562 shall be 80 to 90 Kreb units.
- b. **Weight per gallon:** The weight per gallon shall be at least 11.5 pounds.
- c. **Drying time:** The catalyst/resin ratio shall be adjusted by the operator so that the applied line shall dry to a no-tracking condition in 15 minutes or less when applied at an application temperature of 77 degrees F to 100 degrees F, a substrate temperature of at least 60 degrees F, a wet thickness of 15 to 25 mils, and with 10 to 15 pounds of glass beads conforming to the requirements of Section 234 applied per gallon. No-track time shall be determined by passing over the line with a passenger car or pickup truck at a speed of 25 to 35 mph in a simulated passing maneuver. A line showing no visual deposition of the material to the pavement surface when viewed from a distance of 50 feet shall be considered to show “no track” and to conform to the requirements for time to “no track.”
- d. **Catalyst:** The catalytic component of the system shall be a commercially available type recommended by the manufacturer of the polyester. The peroxide shall not be exposed to any form of heat, such as direct sunlight, radiators, open flame, or sparks as heat may cause the organic peroxide to decompose violently or burn if ignited. The peroxide shall not come into contact with easily oxidized metals, such as copper, brass, mild steel, or galvanized steel as this can also initiate a violent reaction.

- e. **Weight loss:** Beaded catalyzed material shall have a weight loss of not more than 125 milligrams after 1,000 revolutions when abraded in accordance with the requirements of Federal Test Method Standard No. 141b, Method 6192, using CS-17 wheels with a 1,000-gram load on each wheel.
 - f. **Shelf life:** The shelf life of uncatalyzed material shall be at least 6 months when stored in a cool area below 85 degrees F.
 - g. **Durability and wear resistance:** Material shall be designed to provide a life expectancy of at least 3 years under an average daily traffic count per lane of approximately 9,000 vehicles.
 - h. **Hiding:** The marking shall show a dry hiding quality that will yield a contrast ratio of at least 0.96 with the Mostest Black and White Power Chart, Form 03B, when drawn down at a 15-mil wet film thickness. Readings will be determined in accordance with the requirements of ASTM E 1349 using CIE 1931, 2 degrees standard observer and CIE standard Illuminant D65.
- (e) **Epoxy-Resin Pavement Marking Material (Type B, Class III):** Epoxy-resin is a two-component pavement marking material suitable for use on both asphalt and hydraulic cement concrete surfaces. Pigment, beads, and filler shall be well dispersed in the resin. Material shall be free from skins, dirt, and foreign objects and shall conform to the following requirements:

1. Composition

Component	ASTM	White	Yellow
Epoxy resins	D1652	Max. 82%	Max. 77%
Titanium dioxide	D476, Type IV	Min. 18%	—
Pigments	—	—	Min. 23%

2. Physical requirements:

- a. **Hardness:** Hardness, Shore D, determined in accordance with the requirements of ASTM D2240, shall be 75 to 100.
- b. **Tensile strength:** Tensile strength, determined in accordance with the requirements of ASTM D638, shall be at least 6,000 pounds per square inch after the material has cured for 72 hours at 73 ± 4 degrees F.
- c. **Compressive strength:** Compressive strength, determined in accordance with the requirements of ASTM D695, shall be at least 12,000 pounds per square inch after the material has cured for 72 hours at 73 ± 4 degrees F.
- d. **Adhesion to concrete:** Adhesion, determined in accordance with the requirements of ACI 503, shall be at 100 percent concrete failure after the material has cured for 72 hours at 73 ± 4 degrees F. Concrete used for the test shall have a tensile strength of at least 300 pounds per square inch and shall be 90 degrees F when the material is applied.

- e. **Drying time:** Material shall dry to a “no-track” condition in 15 minutes or less at pavement temperatures from 50 degrees F to 120 degrees F and under all humidity conditions providing the pavement is dry. No-track time shall be determined by passing over the line with a passenger car or pickup truck at a speed of 25 to 35 mph in a simulated passing maneuver. A line showing no visual deposition of the material to the pavement surface when viewed from a distance of 50 feet shall be considered to show “no-track” and to conform to the requirements for time to “no-track.”
 - f. **Weight per epoxy equivalent:** The weight per epoxy equivalent of Part A of the epoxy pavement marking material shall be within ± 50 of the target value provided by the manufacturer when tested in accordance with the requirements of ASTM D1652.
 - g. **Total amine value:** The total amine value of Part B of the epoxy pavement marking material shall be within ± 50 of the target value provided by the manufacturer when tested in accordance with the requirements of ASTM D2074.
 - h. **Durability and wear resistance:** Material shall be designed to provide a life expectancy of at least 3 years under an average daily traffic count per lane of approximately 9,000 vehicles.
 - i. **Abrasion resistance:** The wear index shall be no greater than 80 when abrasion resistance is tested in accordance with the requirements of ASTM D4060.
 - j. **Hiding:** The marking shall show a dry hiding quality that will yield a contrast ratio of at least 0.96 with the Moresst Black and White Power Chart, Form 03B, when drawn down at a 15-mil wet film thickness. Readings will be determined in accordance with the requirements of ASTM E 1349 using CIE 1931, 2 degrees standard observer and CIE standard Illuminant D65.
- (f) **Plastic-Backed Preformed Tape Pavement Marking Material (Type B, Class IV):** Plastic-backed preformed tape shall conform to the requirements of ASTM D4505 for a Type I or VI, Grade B, C, D, or E, material and any additions and/or exceptions indicated herein. Tape shall be suitable for use on both asphalt and hydraulic cement concrete surfaces and shall be capable of being applied to previously applied marking material of the same composition under normal conditions of use. Tape shall be selected from the Department’s approved products list. Tape products will be included on the Department’s approved products list after the Department determines conformance to the specifications on both asphalt and hydraulic cement concrete roadways. Determination of conformance will include, but not be limited to, the evaluation of test data from AASHTO’s National Transportation Product Evaluation Program (NTPEP) or other Department-approved facilities.
- 1. **Thickness (no adhesive):** The thickness shall be at least 60 mils and no more than 90 mils.
 - 2. **Skid resistance:** Skid resistance requirements for a Type I material shall be the same as those for a Type VI material.
 - 3. **Initial retroreflectivity:** Initial retroreflectivity requirements for a Type VI material shall be the same as those for a Type I material.

4. **Maintained retroreflectivity, durability and adhesion:** Maintained retroreflectivity, durability, and adhesion shall conform to the following requirements after being installed on the test deck for 1 year:
 - a. **Maintained retroreflectivity:** The photometric quantity to be measured is the coefficient of retroreflected luminance (R_L) in accordance with the requirements of ASTM E1743 for 15-meter geometry and ASTM E1710 for 30-meter geometry. R_L shall be expressed in millicandelas per square foot per foot-candle and shall be at least either 150 for 15-meter or 100 for 30-meter when measured in the skipline or centerline areas.
 - b. **Durability:** Tape shall have a durability rating of at least 4 when determined in the wheel path area.
 - c. **Adhesion:** No line shall be displaced, be torn or missing.

- (g) **Construction Pavement Marking Materials:** Construction pavement markings shall consist of removable tape, non-retroreflective black removable tape, and temporary pavement marking material. Construction pavement marking materials shall be selected from the Department's approved products list. Products will be included on the Department's approved products list after the Department determines their conformance to the specifications on both asphalt and hydraulic cement concrete roadways and the manufacturer has supplied information to the Department indicating conformance to the following warranty requirements for the tape products except that Type E material will be evaluated only for asphalt concrete roadways. Determination of conformance will include, but not be limited to, the evaluation of test data from AASHTO's National Transportation Product Evaluation Program (NTPEP) or other Department-approved facilities.
 1. **Removable tape (Type D, Class I and II):** Removable tape shall be suitable for use on both asphalt and hydraulic cement concrete surfaces and shall conform to the following requirements:
 - a. **Initial skid resistance:** The initial skid resistance value shall be at least 45 BPN.
 - b. **Warranty:** The manufacturer shall provide a full manufacturer's warranty on its product that shall cover the retroreflectivity, removability, and adhesiveness. The warranty period shall be no less than 90 days, beginning on the date of installation, and shall include all material and labor costs when the material is installed in accordance with the manufacturer's recommendations.
 - c. **Maintained retroreflectivity, removability, and adhesion:** Maintained retroreflectivity, removability, and adhesion shall conform to the following requirements after the material has been installed on the test deck for 90 days:
 - (1) **Maintained retroreflectivity:** The photometric quantity to be measured is the coefficient of retroreflected luminance (R_L) in accordance with the requirements of ASTM E1743 for 15-meter geometry and ASTM E1710 for 30-meter geometry. R_L shall be expressed in millicandelas per square foot per foot-candle and shall be at least the following values for either 15-meter or 30-meter when measured in the wheel path area.

Coefficient of Retroreflected Luminance (R_L)

Color	Type D, Class I (15 meter)	Type D, Class I (30 meter)	Type D, Class II (15 meter)	Type D, Class II (30 meter)
White	150	100	225	150
Yellow	100	65	150	100

- (2) **Removability:** The removability value shall be at least 8 for materials submitted to NTPEP prior to the year 1998. For materials submitted to NTPEP in the year 1998 and later, the internal tape strength value shall be no greater than 3 and the adhesive bond value shall be no greater than 7. Values shall be the average of the three monthly readings for the transverse line.
- (3) **Adhesion:** No line shall be displaced, be torn or missing.
2. **Non-retroreflective black removable tape (Type E):** Non-retroreflective black removable tape shall be suitable for use on asphalt concrete surfaces and shall conform to the following:
- a. **Initial skid resistance:** The initial skid resistance value shall be at least 45 BPN.
- b. **Warranty:** The manufacturer shall provide a full manufacturer's warranty on its product that shall cover removability and adhesiveness. The warranty period shall be no less than 90 days, beginning on the date of installation, and shall include all material and labor costs when the material is installed in accordance with the manufacturer's recommendations.
- c. **Removability and adhesion:** Removability and adhesion shall conform to the following requirements after being installed on the test deck for 90 days:
- (1) **Removability:** The removability value shall be at least 8 for materials submitted to NTPEP prior to the year 1998. For materials submitted to NTPEP in the year 1998 and later, the internal tape strength value shall be no greater than 3 and the adhesive bond value shall be no greater than 7. Values shall be the average of the three monthly readings for the transverse line.
- (2) **Adhesion:** No line shall be displaced, from its original position or be torn or missing.
3. **Temporary pavement marking material (Type F, Classes I and II):** Temporary pavement marking material shall be suitable for use on asphalt and hydraulic cement concrete surfaces and shall conform to the following:
- a. **Paint products:**
- (1) **Settling properties:** The settling rating shall be at least 8 when tested in accordance with the requirements of ASTM D869.

- (2) **Freeze-thaw and heat stability:** Paint shall show no coagulation or change in viscosity greater than ± 5 KU when tested in accordance with the NTPEP test procedure.
- (3) **Water resistance:** Paint shall show no blistering, peeling, wrinkling, softening, or loss of adhesion when tested in accordance with the NTPEP test procedure.
- (4) **VOC:** The VOC content shall be no greater than 150 grams/liter when tested in accordance with EPA Method 24.

b. **Tape products:**

- (1) **Initial skid resistance:** The initial skid resistance value shall be at least 45 BPN.
- (2) **Warranty:** The manufacturer shall provide a full manufacturer’s warranty on its product that shall cover retroreflectivity, removability, and adhesiveness. The warranty period shall be no less than 90 days, beginning on the date of installation, and shall include all material and labor costs when the materials is installed in accordance with the manufacturer’s recommendations.
- (3) **Adhesion:** No line shall be displaced, from its original position or be torn or missing after being installed on the test deck for 90 days.

c. **All products (including paint and tape products):**

- (1) **Thickness:** The thickness shall be no greater than 40 mils.
- (2) **Maintained retroreflectivity and durability:** Maintained retroreflectivity and durability shall conform to the following requirements after the material has been installed on the test deck for 90 days:
 - a) **Maintained retroreflectivity:** The photometric quantity to be measured is the coefficient of retroreflected luminance (R_L) in accordance with the requirements of ASTM E1743 for 15-meter geometry and ASTM E1710 for 30-meter geometry. R_L shall be expressed in millicandelas per square foot per foot-candle and shall be at least the following values for either 15-meter or 30-meter when measured in the wheel path area.

Coefficient of Retroreflected Luminance (R_L)

Color	Type F, Class I (15 meter)	Type F, Class I (30 meter)	Type F, Class II (15 meter)	Type F, Class II (30 meter)
White	150	100	290	190
Yellow	100	65	190	125

- b) **Durability:** Marking material shall have a durability rating of at least 4 when determined in the wheel path area.

SECTION 247—REFLECTIVE SHEETING

247.01—Description

This specification covers reflective sheeting used on traffic control devices to provide a retroreflective surface or message. The color of the reflective sheeting shall be as specified in the Contract Documents. Reflective sheeting shall be certified in accordance with the requirements of Section 106.06.

247.02—Detail Requirements

Reflective sheeting shall be selected from the Department's approved products list. Reflective sheeting products will be included on the Qualified Products List after the Department determines conformance to the Specifications and the manufacturer has supplied written information indicating conformance to the warranty requirements of Section 247.03. Determination of conformance will include, but not be limited to, the evaluation of test data from AASHTO's National Transportation Product Evaluation Program (NTPEP) or other Department-approved facilities. When color test data provided by NTPEP or other Department-approved facilities are evaluated, color shall have been maintained within the color specification limits for the duration of the outdoor weathering test.

- (a) **Reflective sheeting used on signs (except those specifically indicated otherwise herein), vertical panels (Group 2 channelizing devices), traffic gates, and the "STOP" side of sign paddles (hand signaling device)** shall conform to the requirements of ASTM D4956 for a Type III material.

Color shall conform to the requirements of 23 CFR, Part 655, Subpart F, Appendix Tables 1 and 1A.

The maintained coefficient of retroreflection of the sheeting after 3 years on the test deck shall conform to the requirements of ASTM D4956.

- (b) **Reflective sheeting used on cones, tubular delineators, drums, and permanent sand barrels** shall conform to the requirements of ASTM D4956 including supplementary requirement S2 for a Type III reboundable material. Color shall conform to the requirements of 23 CFR, Part 655, Subpart F, Appendix Tables 1 and 1A, except the minimum daytime luminance factor for white shall be 25 when used on cones and tubular delineators. The following supplementary table shall apply for cones, tubular delineators, and drums:

Minimum Coefficient of Retroreflection R_A (Candelas per footcandle per square foot)			
Observation Angle (°)	Entrance Angle (°)	White	Orange
0.2	+50	75	25
0.5	+50	35	10

Reflective sheeting used on cones and tubular delineators is not required to be tested by NTPEP.

- (c) **Reflective sheeting used to delineate the trailer’s back frame of portable changeable message signs, arrow boards and portable lights** shall conform to the requirements of 49 CFR 571.108 for a Grade DOT-C2 truck conspicuity marking. References to ASTM specifications therein shall be interpreted to mean the latest version of the specification regardless of the date indicated in the reference. Color shall conform to the requirements of 23 CFR, Part 655, Subpart F, Appendix Tables 1 and 1A. This reflective sheeting is not required to be tested by NTPEP.

- (d) **Reflective sheeting used on orange construction and maintenance activity signs, barrier vertical panels installed on concrete traffic barrier service, rear panel of truck-mounted attenuators, temporary impact attenuators (except sand barrels), and the “SLOW” side of sign paddles** shall be fluorescent prismatic lens type conforming to the following:

Minimum Coefficient of Retroreflection R_A
(Candelas per footcandle per square foot)

Observation Angle (°)	Entrance Angle (°)	Fluorescent Orange
0.2	-4	140
0.2	+30	90
0.2	+40	24
0.5	-4	90
0.5	+30	50
0.5	+40	15
1.0	-4	10
1.0	+30	5
1.0	+40	3

The maintained coefficient of retroreflection of the sheeting after 1 year on the test deck shall be at least 50 percent of the minimum coefficient of retroreflection specified.

Color shall conform to the requirements of 23 CFR, Part 655, Subpart F, Appendix Tables 3 and 3A.

Impact resistance shall conform to the requirements of ASTM D4956.

- (e) Reflective sheeting used on temporary sand barrels shall be fluorescent orange prismatic lens reboundable type conforming to the following:

Minimum Coefficient of Retroreflection R_A
(Candelas per footcandle per square foot)

Observation Angle (°)	Entrance Angle (°)	Fluorescent Orange
0.2	-4	200
0.2	+30	120
0.2	+50	40
0.5	-4	80
0.5	+30	50
0.5	+50	30

The maintained coefficient of retroreflection of the sheeting after 1 year on the test deck shall be at least 50 percent of the minimum coefficient of retroreflection specified.

Color shall conform to the requirements of 23 CFR, Part 655, Subpart F, Appendix Tables 3 and 3A.

Reflective sheeting shall conform to the supplementary requirement S2 of ASTM D4956.

- (f) **Reflective sheeting used on object markers, nose of guardrails, permanent impact attenuators (except sand barrels), standard road edge delineators, special road edge delineators, barrier delineators, guardrail delineators, interstate road edge delineators, chevron panels, bridge end panel signs (VW-13), and railroad advance warning signs (including any supplemental plaques)** shall conform to the requirements of ASTM D4956 for a Type IX material with the following changes to the minimum coefficient of retroreflection R_A at the 1.0 observation angle. Color shall conform to the requirements of 23 CFR, Part 655, Subpart F, Appendix Tables 1 and 1A.

**Minimum Coefficient of Retroreflection R_A
(Candelas per footcandle per square foot)**

Observation Angle (°)	Entrance Angle (°)	White	Yellow
1.0	-4	28	22
1.0	+30	16	12

- (g) **Reflective sheeting used on Type III barricades** shall be prismatic lens type conforming to the following:

**Minimum Coefficient of Retroreflection R_A
(Candelas per footcandle per square foot)**

Observation Angle (°)	Entrance Angle (°)	White	Yellow
0.2	-4	600	200
0.2	+30	270	120
0.2	+40	50	20
0.5	-4	220	80
0.5	+30	105	43
0.5	+40	40	15
1.0	-4	12	4
1.0	+30	10	3
1.0	+40	10	3

The maintained coefficient of retroreflection of the sheeting after 1 year on the test deck shall be at least 50 percent of the minimum coefficient of retroreflection values specified.

Color shall conform to the requirements of 23 CFR, Part 655, Subpart F, Appendix Tables 1 and 1A.

Impact resistance shall conform to the requirements of ASTM D4956.

(h) **Reflective sheeting used on the following signs** shall be fluorescent yellow-green high-observation angle prismatic lens type conforming to the following:

- Bicycle Crossing sign (W11-1) including supplemental plaques
- Pedestrian Crossing sign (W11-2) including supplemental plaques
- Playground sign (W15-1) including supplemental plaques
- DEAF CHILD AREA sign including supplemental plaques
- WATCH FOR CHILDREN sign including supplemental plaques
- School Signing consisting of the following:
 - School Crossing sign (S1-1)
 - School Bus Stop Ahead sign (S3-1)
 - SCHOOL plaque (S4-3)
 - School Portion of the School Speed Limit sign (S5-1)
 - Supplemental plaques used with these signs

Minimum Coefficient of Retroreflection R_A
(Candelas per footcandle per square foot)

Observation Angle (°)	Entrance Angle (°)	Fluorescent Yellow-Green
0.2	-4	325
0.2	+30	203
0.5	-4	238
0.5	+30	108
1.0	-4	63
1.0	+30	35

The maintained coefficient of retroreflection of the sheeting after 3 years on the test deck shall be at least 50 percent of the minimum coefficient of retroreflection values specified.

Color shall conform to the requirements of 23 CFR, Part 655, Subpart F, Appendix Tables 3 and 3A.

Impact resistance shall conform to the requirements of ASTM D4956.

(i) **Reflective sheeting used on retroreflective rollup signs** shall conform to the following:

Minimum Coefficient of Retroreflection R_A
(Candelas per footcandle per square foot)

Observation Angle (°)	Entrance Angle (°)	White	Fluorescent Orange
0.2	-4	300	200
0.2	+30	180	125
0.2	+50	90	50
0.5	-4	200	72
0.5	+30	75	36
0.5	+50	45	20

Color shall conform to the requirements of 23 CFR, Part 655, Subpart F, Appendix Tables 1 and 1A for white and Appendix Tables 3 and 3A for fluorescent orange. This reflective sheeting is not required to be tested by NTPEP.

- (j) **Reflective sheeting used for the background on positive contrast guide signs** shall conform to the requirements of ASTM D4956 for a Type III, VII, VIII, IX, or X material. Positive contrast letters, numerals, symbols, arrows, and borders used on guide signs shall be fabricated from prismatic sheeting conforming to the requirements of ASTM D4956 for a Type VII, VIII, IX, or X material.

Color shall conform to the requirements of 23 CFR, Part 655, Subpart F, Appendix Tables 1 and 1A.

The maintained coefficient of retroreflection of the sheeting after 3 years on the test deck shall conform to the requirements of ASTM D4956.

247.03—Warranty Requirements

The reflective sheeting manufacturer shall provide the following warranties to the Department on its products:

- (a) **Type III Sheeting (Permanent Use):** 12-year warranty with 10 years being 100 percent full replacement covering all material and labor costs associated with fabrication and installation of the sign or device and the final 2 years being 100 percent sheeting replacement cost.
- (b) **Type VIII, IX and High Observation Angle Prismatic Sheeting (Permanent Use):** 10-year warranty with 7 years being 100 percent full replacement covering all material and labor costs associated with fabrication and installation of the sign or device and the final 3 years being 100 percent sheeting replacement cost.
- (c) **Type III, Prismatic and Rollup Sign Sheeting (Work Zone Use) and Grade DOT-C2 Truck Conspicuity Marking:** 3-year full replacement warranty covering all material and labor costs associated with fabrication of the sign or device.

The warranty shall cover the loss of retroreflectivity, loss of colorfastness, cracking, and any other conditions inherent to the sheeting including inks and overlay film that cause it to be ineffective in providing the direction to the motorists as intended.

The minimum values of retroreflectivity maintained during the warranty period shall be the same as those required for the maintained coefficient of retroreflection values as indicated herein or as specified in ASTM D4956 if they do not exist herein. For reflective sheeting indicated in Section 247.02(i), the minimum values of retroreflectivity maintained during the warranty period shall be no less than 50 percent of the minimum coefficient of retroreflection values specified herein.

Loss of colorfastness is considered to have occurred if the color of the sheeting is not within the color specification limits in 23 CFR, Part 655, Subpart F, Appendix, during the warranty period.

SECTION 248—STONE MATRIX ASPHALT CONCRETE

248.01—Description

These specifications cover the materials used to produce stone matrix asphalt (SMA) concrete pavement. SMA shall be in accordance to this specifications and Section 211. SMA consists of a combination of coarse aggregate, fine aggregate, mineral filler, fiber additives, and liquid asphalt binder mechanically mixed in a plant to produce a stable gap-graded asphalt concrete paving mixture.

248.02—Materials

(a) **Coarse Aggregate:** Coarse aggregate shall conform to the following requirements when tested in accordance with the specified tests:

1.	Los Angeles Abrasion	AASHTO T96	40% max.
2.	Flat and Elongated Particles: Measured on No. 4 retained, 3 to 1	VTM-121	20% max.
	5 to 1		5% max.
3.	Magnesium Sulfate Soundness Loss, 5 cycles	AASHTO T104	15% max.
4.	Particles retained on No. 4 sieve shall have at least 1 fractured face	ASTM D5821	100% min.
	2 fractured faces		90% min.
5.	Absorption	AASHTO T 85	2% max.

Except for the determination of flat and elongated particles (Section 248.02(a)2), the aggregate properties specified are for each stockpile of coarse aggregate material designated on the job mix form (Form No. TL-127). The material contained in each stockpile shall meet the minimum or maximum criteria specified.

For flat and elongated particles, these values are based on the mathematical blend of the coarse aggregate material designated on the job mix form (TL-127). During production,

these values are based on the SMA material sampled during the acceptance process (QC testing).

The use of slag will not be permitted.

- (b) **Fine Aggregate:** Fine aggregate shall consist of a blend of 100 percent crushed aggregate. The magnesium sulfate soundness loss in 5 cycles shall not exceed 20 percent. In addition, the liquid limit shall not exceed 25 as determined in accordance with AASHTO T89.
- (c) **Asphalt Binder:** Asphalt binders shall be performance-graded binder PG 70-22 or polymer-modified binder PG 76-22 conforming to the requirements of the mix designation (M) as designated by the Department. The supplier shall certify to the Department that the binder complies with the requirements for all properties of that grade as specified in AASHTO M320 (Provisional Specification MP-1) for performance-graded asphalt binder. This certification shall be based on testing performed on samples of binder provided to the Contractor for incorporation into the mixture. Certification based on testing performed on laboratory-produced binders will not be acceptable.

The Contractor shall submit to the Engineer for Department review the source, formulation, and PG grading of the binder at least 15 days prior to the production of the SMA mixture.

During mixture production, testing to determine the binder PG grade will be performed by the Department on samples taken from storage at the hot-mix asphalt plant as directed by the Engineer. The Contractor shall be responsible for obtaining the sample of binder when requested. In the event it is determined that the binder does not comply with the requirements of the specified PG grade, production shall be stopped until further testing indicates that the problem has been corrected.

- (d) **Mineral Filler:** Mineral filler shall consist of finely divided mineral matter such as rock or limestone dust or other suitable material. Hydrated lime and fly ash will not be allowed. Up to two mineral fillers may be blended to comply with the mineral filler requirements. Mineral filler shall conform to the requirements of Section 201 with the following modifications. The mineral filler or mineral filler blend used in surface and intermediate SMA shall have a minimum of 55 percent passing the No. 200 sieve. At the time of use, it shall be sufficiently dry to flow freely and be essentially free from agglomerations.
- (e) **Fiber Additive:** Cellulose fiber in either loose or pelletized form shall be used. The minimum dosage rate for cellulose is 0.3 percent by weight of the total mixture. During production, the Department may require the percentage of fiber additive to be increased if visual inspection or draindown testing on plant-produced material indicates that draindown in excess of 0.3 percent by weight of the mixture is occurring as determined in accordance with VTM-100. Allowable tolerances of fiber dosage shall be ± 10 percent of the required fiber weight.

NOTE: When using pelletized fiber, the dosage rate shall be adjusted to comply with the specified minimum dosage rates for cellulose fiber. Pelletized fiber consists of cellulose fiber and a binder. The specified minimum dosage rates are based on fiber content only. Therefore, the amount of pelletized fiber added shall typically be higher than for loose fiber.

Fibers will be accepted based on the manufacturer's certification.

TABLE II-23
Cellulose Fiber Properties

Sieve Analysis		
Method A: Alpine Sieve¹ Analysis		
Fiber Length:		0.25 inch max.
Passing	No. 100 Sieve	70% ($\pm 10\%$)
Method B: Mesh Screen² Analysis		
Fiber Length:		0.25 inch max.
Passing	No. 20 Sieve	85% ($\pm 10\%$)
	No. 40 Sieve	65% ($\pm 10\%$)
	No. 140 Sieve	30% ($\pm 10\%$)
Ash Content³		18% ($\pm 5\%$) non-volatile
pH⁴		7.5 (± 1.0)
Oil Absorption⁵		5.0 (± 1.0) (times fiber weight)
Moisture Content⁶		<5%

¹*Method A: Alpine Sieve Analysis.* Performed using an Alpine Air Jet Sieve (Type 200 LS). A representative 5-gram sample of fiber is sieved for 14 minutes at a controlled vacuum of 22 inches (± 3 inches) of water. The portion remaining on the screen is weighed.

²*Method B: Mesh Screen Analysis.* This test is performed using standard Nos. 20, 40, 60, 80, 100, and 140 sieves, nylon brushes, and a shaker. A representative 10-gram sample of fiber is sieved, using a shaker and two nylon brushes on each screen. The amount retained on each sieve is weighed and the percentage passing calculated.

³*Ash Content:* A representative 2- to 3-gram sample of fiber is placed in a tared crucible and heated between 1100 and 1200 degrees F for not less than 2 hours. The crucible and ash are cooled in a desiccator and reweighed.

⁴*pH Test:* Five grams of fiber is added to 3.5 ounces of distilled water, stirred, and allowed to set for 30 minutes. The pH is determined with a probe calibrated with a pH 7.0 buffer.

⁵*Oil Absorption Test:* Five grams of fiber is accurately weighed and suspended in an excess of mineral spirits for not less than 5 minutes to ensure total saturation. It is then placed in a screen mesh strainer (with a hole size of approximately 0.5 square millimeter), and shaken on a wrist action shaker for 10 minutes (approximately 1 1/4-inch motion at 20 shakes/minute). The shaken mass is then transferred without touching to a tared container and weighed. Results are reported as the amount (number or times its own weight) the fibers are able to absorb.

⁶*Moisture Content*:* Ten grams of fiber is weighed and placed in a 250 degree F forced air oven for 2 hours. The sample is then reweighed immediately upon removal from the oven.

- (f) **RAP:** The use of RAP will not be permitted.

248.03—Composition of SMA Mixture

The SMA mixture shall be designed and tested using a gyratory compactor and shall conform to the requirements listed in Table II-24 and Table II-25 One percent hydrated lime will be required as an antistripping additive. An alternative antistripping additive can be used only if permitted by the Engineer.

248.04—Acceptance

A lot will be considered acceptable for gradation and asphalt content if the mean of the test results obtained is within the tolerance allowed from the job-mix formula. The production tolerances for the control sieves and asphalt content shall be as follows:

TABLE II-24
SMA Design Range

Percentage by Weight Passing Square Mesh Sieves (in)								
Type No. (See Note)	1	3/4	1/2	3/8	No. 4	No. 8	No. 30	No. 200
<i>Surface Mixes</i>								
SMA 12.5	—	100	85-95	80 max.	22-30	16-24	15-20	10-12
SMA 9.5	—	100	90-100	70-85	25-40	15-25	—	10-12
<i>Intermediate Mixes</i>								
SMA 19.0	100	85-95	50-60	30-45	—	16-24	12-16	8-10

Note: The required PG binder will be shown in parentheses as part of the mix type on the plans or proposal, e.g., SMA 12.5 (76-22).

TABLE II-25
SMA Mixture Requirements

Mix Type	VTM ¹ (%)	VMA		VCA	AC		Design Gyrations	Specimen Height ³
		Design (Min. %)	Production (Min. %)	Design and Production ² (%)	(Min. %)	Draindown (%)		
SMA 9.5	2.0-4.0	18.0	17.0	<VCA _{DRC}	6.3	0.3 max	75	115
SMA 12.5	2.0-4.0	18.0	17.0	<VCA _{DRC}	6.3	0.3 max	75	115
SMA19.0	2.0-4.0	17.0	16.0	<VCA _{DRC}	5.5	0.3 max	75	115

¹Asphalt content shall be selected at the midpoint of the VTM range but shall not be less than the minimum specified.

²The voids in coarse aggregates (VCA) of the dry rodded condition (DRC) and mix shall be determined in accordance with VTM-99.

³Specimen height after compaction shall be between 4.25 and 4.75 inches.

The fines-effective asphalt ratio shall be 1.2-2.0

NOTE: The SUPERPAVE gyratory compactor (SGC) shall be from the Department's approved list maintained by the Department's Materials Division. Gyratory procedures shall be performed in accordance with VTM-99. Calculations for volumetrics shall be performed in accordance with VTM-57 and VTM-58, 6-inch specimens.

Draindown testing shall be conducted in accordance with VTM-100.

Process Tolerance

Tolerance on Each Laboratory Sieve (in) and Asphalt Content (+/-%)									
No. Tests	Top	3/4	1/2	3/8	No. 4	No. 8	No. 30	No. 200	AC
	Size								
1	0.0	8.0	8.0	8.0	6.0	6.0	6.0	4.0	0.60
2	0.0	5.7	5.7	5.7	4.3	4.3	4.3	2.8	0.43
3	0.0	4.4	4.4	4.4	3.3	3.3	3.3	2.2	0.33
4	0.0	4.0	4.0	4.0	3.0	3.0	3.0	2.0	0.30
8	0.0	2.8	2.8	2.8	2.1	2.1	2.1	1.4	0.21

The production tolerance for the specimen height after compaction is 4.25 to 4.75 inches.

The Contractor shall check and report the VCA of the mix during production for each gyratory sample. If the VCA of the mix exceeds the VCA of the DRC, the Contractor shall stop production and notify the Engineer. Production shall not resume until the Contractor has taken corrective action.

The Contractor shall check and report the percentage of Flat and Elongated Particles (F&E) in the Coarse Aggregates of the mix during production. When the SMA material is sampled for acceptance (gradation and AC content); one of the four sub-lots must be selected for F&E verification. The F&E testing will be performed on the coarse aggregate material retained on the #4 sieve (per ASTM VTM-121) after the gradation analysis is performed. At initial start-up of production, the F&E shall be determined for each of the first two lots of material produced. If passing results are obtained on each sample in the first two lots, then F&E testing shall be performed on a frequency of every second lot of material produced (i.e. – Lots 4, 6, 8, etc.). If the F&E of the mix exceeds the specified limits, the Contractor shall stop production and notify the Engineer. Production shall not resume until the Contractor has taken corrective action and the Engineer has approved the corrective action. Once production has resumed, the Contractor shall determine the F&E of the mix for two consecutive lots. If passing results are obtained for these two lots, then the F&E testing frequency shall return to every second lot of material produced.

In the event the Department determines that the mixture being produced does not conform to the approved job-mix formula and volumetric properties in Table II–25 based on Department or Contractor's test results, the Contractor shall immediately make corrections to bring the mixture into conformance with the approved job-mix formula or cease paving with that mixture.

Subsequent paving operations, using either a revised or other job-mix formula which has not been verified as described herein, shall be limited to a test run of 300 tons maximum if such material is to be placed in Department project work. No further paving for the Department using that specific mixture shall occur until the acceptability of the mixture being produced has been verified using the 300-ton constraint.

248.05—SMA Mixing Plant

Plants used for the preparation of the SMA mixture shall conform to the following:

- (a) **Handling of Mineral Filler:** Adequate dry storage shall be provided for the mineral filler that will, at a minimum, consist of a waterproof cover that shall completely cover the stockpile at all times. Provisions shall be made for metering of the filler into the mixture uniformly and in the desired quantities. In a batch plant, mineral filler shall be added directly into the weigh hopper. In a drum plant, mineral filler shall be added directly onto the cold feed belt. Equipment shall be capable of accurately and uniformly metering the large amounts of mineral filler up to 25 percent of the total mix.
- (b) **Fiber Addition:** Adequate dry storage shall be provided for the fiber additive, and provisions shall be made for accurately and uniformly metering fiber into the mixture at plus or minus 10 percent of the desired quantities.

Introduction of loose or pelletized fiber shall require a separate system that can accurately proportion, by weight, the required quantity of fiber in such a manner as to ensure consistent, uniform blending into the mixture at all rates of production and batch sizes. This supply system shall be interlocked with the other feeding devices of the plant system, and sens-

ing devices shall provide for interruption of mixture production if the introduction of fiber fails.

Batch Plant: Loose fiber or pelletized fiber shall be added through a separate inlet directly into the weigh hopper above the pugmill. The addition of fiber shall be timed to occur during the hot aggregate charging of the hopper. Adequate dry mixing time is required to ensure proper blending of the aggregate and fiber stabilizer. Therefore, dry mixing time shall typically be increased 5 to 15 seconds. Wet mixing time shall typically be increased at least 5 seconds for cellulose fibers to ensure adequate blending with the asphalt cement.

When fiber is used, the fiber supply system shall include low level and no flow indicators and a printout of the date, time, and net batch weight of fiber.

Drum Mix Plant: When fiber is used, the fibers shall be added in such a manner as not to be entrained into the exhaust gases of the drum plant. The fiber supply system shall include low level and no flow indicators and a printout of status of feed rate in pounds per minute.

When pelletized fibers are used, they shall be added directly into the drum mixer through the RAP inlet or a specialized fiber inlet. Operation of the drum mixer shall be such as to ensure complete blending of the pelletized fiber into the mix.

- (c) **Hot Mixture Storage:** When the hot mixture is not hauled immediately to the project and placed, suitable bins for storage shall be provided. Such bins shall be either surge bins to balance production capacity with hauling and placing capacity or storage bins that are heated and insulated and that have a controlled atmosphere around the mixture. The holding times shall be within limitations imposed by the Engineer, based on laboratory tests of the stored mixture. In no case shall the SMA mixture be kept in storage more than 8 hours.
- (d) **Mixing Temperatures:** The recommended plant mixing temperature shall be 315 to 340 degrees F and at no time shall the exceed 350 degrees F.

Division III
ROADWAY CONSTRUCTION

SECTION 301—CLEARING AND GRUBBING

301.01—Description

This work shall consist of clearing, grubbing, removing, and disposing of vegetation, debris, and other objects within the construction limits except for vegetation and objects that are designated to be preserved, protected, or removed in accordance with the requirements of other provisions of these specifications.

301.02—Procedures

If approved by the Engineer, the Contractor may clear and grub to accommodate construction equipment within the right of way up to 5 feet beyond the construction limits at his own expense. The Contractor shall install erosion and siltation control devices prior to beginning clearing or grubbing operations and such devices shall be functional before upland land-disturbing activities take place.

The surface area of earth material exposed by grubbing, stripping topsoil, or excavation shall be limited to that necessary to perform the next operation within a given area. Grubbing of root mat and stumps shall be confined to that area of land which excavation or other land disturbance activities shall be performed by the Contractor within 15 days following grubbing.

Stumps, roots, other perishable material, and nonperishable objects that will be less than 5 feet below the top of earthwork within the area directly beneath the pavement and shoulders shall be removed. However, such material and objects that will be 5 or more than 5 feet below the top of earthwork within the area directly beneath the pavement and shoulders and all such material and objects beneath slopes of embankments shall be left in place unless removal is necessary for installation of a structure. The top of stumps left in place shall be not more than 6 inches above the existing ground surface or low water level.

Branches of trees that overhang the roadway or reduce sight distance and that are less than 20 feet above the elevation of the finished grade shall be trimmed using approved tree surgery practices in accordance with the requirements of Section 601.03(b).

Vegetation, structure, or other items outside the construction limits shall not be damaged. Trees and shrubs in ungraded areas shall not be cut without the approval of the Engineer.

Combustible cleared and grubbed material shall be disposed of in accordance with the following:

- (a) **Trees, limbs, and other timber having a diameter of 3 inches and greater** shall be disposed of as saw logs, pulpwood, firewood, or other usable material; however, treated timber shall not be disposed of as firewood. Not more than 2 feet of trunk shall be left attached to grubbed stumps.

When specified that trees or other timber is to be reserved for the property owner, such material shall be cut in the lengths specified and piled where designated, either within the limits of the right of way or not more than 100 feet from the right-of-way line. When not reserved for the property owner, such material shall become the property of the Contractor.

- (b) **Material less than 3 inches in diameter** shall be used to form brush silt barriers when located within 500 feet of the source of such material when specified on the plans or where directed by the Engineer. Material shall be placed approximately 5 feet beyond the toe of fill in a strip approximately 10 feet wide to form a continuous barrier on the downhill side of fills. Where selective clearing has been done, material shall be piled, for stability, against trees in the proper location. On the uphill side of fills, brush shall be stacked against fills at approximately 100-foot intervals in piles approximately 5 feet high and 10 feet wide. Any such material not needed to form silt barriers shall be processed into chips having a thickness of not more than 3/8 inch and an area of not more than 6 square inches and may be stockpiled out of sight of any public highway for use as mulch.
- (c) **Stumps and material less than 3 inches in diameter** that are not needed to form silt barriers and that are not processed into wood chips shall be handled in accordance with the requirements of Section 106 and Section 107.

301.03—Measurement and Payment

Clearing and grubbing will be measured and paid for in accordance with one of the following methods, as specified:

- (a) **Lump sum basis:** No measurement of the area to be cleared and grubbed will be made.
- (b) **Acre basis:** The work to be paid for will be the number of acres, computed to the nearest 1/10 of an acre, actually cleared and grubbed. Areas within the limits of any existing roadway or local material pit will not be measured.
- (c) **Unit basis:** The work to be paid for will be determined by the actual count of trees, stumps, structures, or other obstructions removed.

These prices shall include disposing of cleared and grubbed material.

When clearing and grubbing is not a pay item, the cost thereof shall be included in the price for other appropriate pay items. Allowance will not be made for clearing and grubbing borrow pits or other local material pits.

Payment will be made under:

Pay Item	Pay Unit
Clearing and grubbing	Lump sum, acre, or unit

SECTION 302—DRAINAGE STRUCTURES

302.01—Description

This work shall consist of installing pipe culverts, endwalls, box culverts, precast concrete and metal arches, storm drains, drop inlets, manholes, spring boxes, junction boxes, and intake boxes and re-

moving and replacing existing structures in accordance with these specifications and in conformity with the lines and grades shown on the plans or as established by the Engineer.

302.02—Materials

- (a) **Pipe** shall conform to the requirements of Section 232 and shall be furnished in accordance with the diameter, wall thickness, class, and strength or corrugation specified for the maximum height of fill to be encountered along the length of the pipe culvert, storm drain, or sewer.
- (b) **End sections** shall conform to the applicable requirements of Section 232. End sections used with rigid pipe shall be concrete. End sections used with asphalt-coated or paved pipe shall not be asphalt coated or paved.
- (c) **Pipe fittings**, such as tees, elbows, wyes, and bends, shall conform to the applicable requirements of Section 232. Fittings shall be of the same type, class, thickness, gage, and strength as the line in which they are used.
- (d) **Steel grates, steel frames, and structural steel** shall conform to the requirements of Section 226 and shall be galvanized in accordance with the requirements of Section 233.
- (e) **Concrete blocks** shall conform to the requirements of Section 222 for masonry blocks.
- (f) **Brick** shall conform to the requirements of Section 222.
- (g) **Hydraulic cement mortar** shall conform to the requirements of Section 218.
- (h) **Cast-in-place concrete** shall conform to the requirements of Section 217 for Class A3.
- (i) **Bedding material** shall conform to the requirements of Section 205.
- (j) **Joint material and gaskets** shall conform to the requirements of Section 212.
- (k) **Gray-iron castings** shall conform to the requirements of Section 224.
- (l) **Reinforcing steel** shall conform to the requirements of Section 223, Grade 40 or 60.
- (m) **Curing materials** shall conform to the requirements of Section 220.

302.03—Procedures

Excavation and backfill operations shall be performed in accordance with the requirements of Section 303. Foundation exploration shall be performed in accordance with the requirements of Section 401 unless otherwise provided herein. Concrete construction shall conform to the requirements of Section 404. Reinforcing steel placement shall conform to the requirements of Section 406. Bearing pile operations shall be performed in accordance with the requirements of Section 403. When specified on the plans or directed by the Engineer, a temporary diversion channel shall be constructed to facilitate installation of a pipe or box culvert.

The Contractor shall be responsible for anticipating and locating underground utilities and obstructions in accordance with the requirements of Section 105.08.

When construction appears to be in close proximity to existing utilities, the trench(es) shall be opened a sufficient distance ahead of the work or test pits made to verify the exact locations and inverts of the utility to determine if changes in line or grade are required for the new work.

When lift holes are provided in concrete pipe or precast box culverts, the Contractor shall install a lift hole plug furnished by the manufacturer in accordance with the requirements of Section 232.02(a)1. After pipe installation and prior to backfilling, plugs shall be installed from the exterior of the pipe or box culvert and snugly seated.

- (a) **Pipe Culverts:** Not more than one type of pipe shall be used in any one pipeline. When the proposal indicates that all types of pipe of one size are combined into one bid item, one bid price shall be submitted for each size of pipe to be used.

When field cutting corrugated metal pipe is permitted by the Engineer, damaged areas of the protective coating shall be repaired in accordance with the requirements of Section 233 for galvanized pipe and in accordance with the manufacturer's recommended procedures for all other metallic or polymer coatings.

1. **Jack and bore method:** The Contractor shall submit to the Engineer a complete plan and schedule for jack and bore pipe installation prior to beginning such work. The submission shall include complete details for dewatering; soil stabilization; jacking and receiving pits; jacks; reaction block; boring equipment; sheeting, shoring, and bracing for protecting the roadbed; installation sequence; materials; and equipment. The Contractor shall not proceed with pipe installation until the plan has been reviewed and accepted by the Engineer.

The jack and bore method shall be applicable for installing concrete pipe 12 through 108 inches in diameter and smooth-wall steel pipe 12 3/4 through 48 inches in diameter.

Pipe shall have a design strength and wall thickness sufficient to withstand the jacking operation and maximum height of fill to be encountered along the length of the pipe.

Construction shall be performed in such a manner that the ground surface above the pipe line will not settle. The hole shall be bored mechanically with a suitable boring assembly designed to produce a smooth, straight shaft and so operated that the completed shaft shall be at the established line and grade. The size of the bored hole shall be of such diameter to provide ample clearance for bells or other joints. The holes shall be bored mechanically. The boring shall be done by using either a pilot hole or a dry bore method.

In operating jacks, even pressure shall be applied to all jacks used. Suitable bracing between jacks and the jacking head shall be provided so that pressure shall be applied to the pipe uniformly around the ring of the pipe. The jacking head shall be of such weight and dimensions that it shall not bend or deflect when full pressure is applied at the jack. The jacking head shall be provided with an opening for the removal of excavated material as the jacking proceeds. The pipe to be jacked shall be set on guides that

are straight and securely braced together in such manner as to support the section of pipe and to direct it in the proper line and grade.

Installation of the pipeline shall immediately follow heading or tunneling excavation. Voids occurring behind the pipe during installation shall be filled with hydraulic cement grout, placed under pressure, upon completion of the jack and bore operation.

Joint sealant material on concrete pipe shall be placed ahead of the jacking frame. The Contractor shall replace or repair, as directed by the Engineer, pipe that is damaged during jacking operations at his own expense. Joints of steel pipe shall be butt welded, watertight, as installation progresses.

When work is stopped, the heading shall be bulkheaded.

When the Contractor encounters an obstruction during the jacking and boring operation that stops the forward progress of the work for more than 60 minutes, the following procedure shall be followed:

- a. The Contractor shall notify the Engineer immediately upon encountering an obstruction that stops the forward progress of the work. The Engineer shall verify that an obstruction has stopped the forward progress of the work in excess of 60 minutes and that the Contractor's efforts to remove or bore through the obstruction have been deliberately and diligently pursued.
- b. The Contractor shall consult with the Engineer and offer appropriate options for consideration. Upon authorization by the Engineer, the Contractor shall proceed with removal of the obstruction by other methods on a force account basis in accordance with the requirements of Section 109.05. Such alternative methods may include tunneling. In the event tunneling is determined to be necessary by the Engineer, the Contractor shall detail a plan for such an operation including all necessary safety and health precautions for workers as required by local, state, and federal regulations as required by the work being performed. Work shall not commence until this plan is received and authorized by the Engineer. The Contractor shall notify the Engineer before resuming work and afford the Engineer the opportunity to witness all work performed by the Contractor. Payment for obstruction removal shall be from the start of removal operations until the successful removal of the obstruction.
- c. Upon removal of the obstruction, the Engineer shall make a determination as to the method to use to proceed with the pipe installation.

2. **Open trench method:**

- a. **Foundation:** The foundation shall be explored below the bottom of the excavation to determine the type and condition of the foundation. However, explorations need not be made for routine entrance or crossover pipe 12 through 30 inches in diameter that is to be installed under fills 15 feet or less in height. Foundation exploration shall extend to a depth equal to 1/2 inch per foot of fill height or 8 inches, whichever is greater. The Contractor shall report the findings of the foundation exploration to the Engineer for approval prior to placing pipe.

Where unsuitable foundation is encountered at the established grade, as determined by the Engineer, such material shall be removed and replaced.

Backfill for areas where unsuitable material has been removed shall be placed and compacted in accordance with the requirements of Section 303.04(g).

- b. **Bedding:** Bedding material for culvert foundations, including foundations in soft, yielding, or otherwise unsuitable material, shall be aggregate No. 25 or 26 conforming to the requirements of Section 205. Where standing or running water is present in the pipe foundation excavation, pipe bedding material shall be aggregate No. 57 for the depth specified on the plans or as directed by the Engineer capped with 4 inches of aggregate No. 25 or 26. Where such conditions are discovered in the field and the Contractor is directed by the Engineer to use No. 57 stone, No. 57 stone will be paid for at the existing contract unit price or, if not in the contract, in accordance with the provisions of Section 109.05.

Pipe bedding shall be lightly and uniformly compacted and shall be carefully shaped so that the lower section of the pipe exterior is in contact with the bedding material for at least 10 percent of the overall height of the pipe. Bedding material shall be shaped to accommodate the bell when bell and spigot pipe is used. The depth of bedding material shall be at least 4 inches or as specified on the plans.

- c. **Placing pipe:** Pipe shall be placed beginning at the downstream end of the pipeline. The lower segment of pipe shall be in contact with the shaped bedding for its entire length. Bell or groove ends of rigid pipe shall be placed facing upstream.

Paved or partially lined pipe shall be placed so that the longitudinal centerline of the paved segment coincides with the flow line.

Pipe will be inspected before backfill is placed. Pipe found to be out of alignment, unduly settled, or damaged shall be taken up and reinstalled or replaced.

- d. **Joining pipe:**

- (1) **Rigid pipe:** The method of joining pipe sections shall be such that ends are fully entered and inner surfaces are reasonably flush and even so as to permit sealing as specified herein.

Joints shall be sealed with any one or combination of the following to form a leak-resistant joint: rubber, preformed plastic, or mastic gaskets from the Department's approved list; oakum and mortar; oakum and joint compound; or cold-applied pipe joint sealer.

Rubber ring gaskets shall be installed to form a flexible, leak-resistant seal. Where oakum is used, the joint shall be caulked with this material and then sealed with mortar or joint compound.

- (2) **Flexible pipe:** Flexible pipe sections shall be aligned and firmly joined by approved coupling bands to form a leak-resistant joint.

- e. **Structural plate pipe, pipe arches, and arches:** Erection shall be in accordance with the manufacturer's assembly diagrams and instruction sheets. Splices in the haunch areas of structural plate pipe arches shall be constructed using the reverse shingle method or the side plates shall be provided without longitudinal seams in the haunch areas. The complete line shall be assembled before backfill is placed. Bolts shall be tightened to a torque of 150 to 250 foot-pounds. If spiraling occurs during installation, bolts shall be loosened and the pipe assembly adjusted to the correct position.
- f. **Arch substructures:** Each side of an arch shall rest in a groove formed into the masonry or on a galvanized angle or channel securely anchored to or embedded in the substructure. Where the span of the arch is more than 15 feet or the skew angle is more than 20 degrees, a metal bearing surface having a width at least equal to the depth of the corrugation shall be provided.

Metal bearings for arches shall be cold-formed galvanized channel conforming to the requirements of ASTM A 569 at least 3/16 inch in thickness, with the horizontal leg securely anchored to the substructure at points spaced on centers of not more than 24 inches. When the metal bearing is not embedded in a groove in the substructure, one vertical leg shall be punched to allow bolting to the bottom row of plates.

- g. **Backfilling:** Class I backfill material shall be crusher run aggregate, No. 25 or 26; aggregate base material, Size 21A or 21B; or flowable fill.

Class I backfill material shall be crusher run aggregate size No. 25 or 26, aggregate base material size 21A or 21B, flowable fill, or crushed glass conforming to the size requirements for crusher run aggregate size 25 and 26.

Regular backfill material outside the neat lines of the Class I areas shown on the Standard PB-1 drawings shall be regular excavation conforming to the requirements of Section 303. Regular and classified backfill shall be placed in uniform layers not more than 6 inches in thickness, loose measurement, before compaction. Each layer of Class I and regular backfill material shall be thoroughly compacted as specified in Section 303.04(g) with the exception that Class I backfill material shall be placed and compacted at a moisture content of optimum to plus 2 percentage points of optimum. Class I backfill material shall be thoroughly compacted under the haunches of pipe culverts. Each layer of Class I and regular backfill material shall be compacted by rolling, tamping with mechanical rammers, or hand tamping with heavy metal tampers with a face of at least 25 square inches. If vibratory rollers are used in the backfill operations, vibratory motors shall not be activated until at least 3 feet of backfill has been placed and compacted over the pipe. Backfill and compaction shall be advanced simultaneously on both sides of the pipe. The fill above the top of the regular backfill shall be installed and completed as specified for embankment construction.

Field density determinations will be performed in accordance with the requirements of VTM-1, VTM-10, or other methods approved by the Engineer.

Concrete pipe with a height of cover greater than that shown in the Standard PC-1 drawings, table for Class V pipe, shall be special design pipe with Method A bedding and backfill in accordance with the requirements of Standard PB-1.

Puddling will not be permitted. Rock more than 2 inches in its greatest dimension shall not be placed within 12 inches of pipe.

Backfill and compaction shall be advanced simultaneously on both sides of the pipe. The fill above the top of the pipe shall be completed as specified for embankment construction unless the induced trench method of installation is used.

3. **Tunneling operations:** The jacked tunneling method shall be applicable for installing concrete pipe 30 through 108 inches in diameter and smooth-wall steel pipe 30 through 48 inches in diameter. Where the plans specifically identify tunneling as the means of pipe installation, tunneling shall be performed by the Contractor as follows:

The tunnel shall be excavated in such a manner and to such dimensions that shall permit placing of the proper supports necessary to protect the excavation. The Contractor shall take the proper precautions to avoid excavating earth or rock or shattering rock beyond the limits of excavation necessary for the safe and proper installation of the pipe. Damage from excavating and blasting, either to surface or subsurface structures, shall be repaired or replaced by the Contractor at his own expense. Adequate provisions shall be made for the safety and health of the workers required by the work being performed.

No pipe shall be placed until the foundation is in a condition satisfactory to the Engineer. Tunnel dimensions shown on the plans are minimum dimensions. Any excess excavation and subsequent backfill, concrete or grout fill shall be at the Contractor's expense. The pipe shall be laid in the tunnel true to line and grade. If required by the plans or if required for safety, suitable steel or timber sheeting, shoring, and bracing shall be used to support the sides and roof of the excavation. Supports may be left in place provided they clear the encasement or carrier pipe. No separate payment shall be made for supports left in place. Installation of the pipeline shall immediately follow tunneling excavation.

If indicated or specified, the entire void between the outside of the pipe and the tunnel walls or the inside face of the tunnel lining shall be grouted in accordance with ASTM C 476 unless the permanent sheeting, bottom, sides, and roof of the tunnel are in a condition satisfactory to the Engineer. The minimum thickness of grout backfill shall be maintained throughout. Grout required for backfill in excess of the excavation tolerances specified herein shall be at the Contractor's expense.

Any pipe damaged during construction operations shall be repaired, if approved by the Engineer, or removed and replaced by the Contractor at his expense.

If corrugated galvanized metal pipe is used, joints may be made by field bolting or by connecting bands, whichever is feasible. When reinforced concrete pipe 24 inches and larger in diameter with tongue-and-groove joints is used for the encasement pipe, the interior joints for the full circumference shall be sealed, packed with mortar, and finished smooth and even with the adjacent section of pipe.

- (b) **Precast Drainage Structures:** Submittal of designs for precast items included in the standard drawings will not be required provided fabrication is in accordance with the standard details. Submittal of designs for precast box culverts on the Department's approved list will not be required provided the Contractor submits a certification that the item will be fabricated in accordance with the preapproved design drawings.

Requests for approval of a precast design shall include detailed plans and supporting computations that have been reviewed and approved by a registered Professional Engineer having at least 5 years experience in structural design of the type of precast structures or components proposed and licensed in the Commonwealth. Concrete shall conform to the requirements of Section 217 unless otherwise specified and have a design strength at 28 days of at least 4,000 pounds per square inch and an air content of 6 ± 2 percent. The design of the concrete mixture and the method of casting, curing, handling, and erecting shall be subject to review by the Engineer. Precast units may be shipped after reaching 85 percent of the design strength as determined by control cylinders tested in accordance with the requirements of Section 404. However, units shall retain their structural integrity during shipment and shall be subject to inspection at the job site. Approval to use precast units shall not be construed as waiving the size and weight hauling limitations specified in Section 107.21.

1. **Standard precast drainage units** shall conform to the material requirements of AASHTO M 199 and the following:
 - a. If the grade on the adjacent gutter is less than 1.5 percent, the grade on the invert of the throat section of the inlet shall be at least 1.5 percent. Precast throats having flat inverts will be permitted in sag locations provided the total length of the required throat opening does not exceed 6 feet.
 - b. Pipe openings in precast drainage units shall not exceed the outside cross-sectional dimensions of the pipes by more than a total of 8 inches regardless of the placement of the pipes, the angles of intersection, or the shapes of the pipes. Pipe openings shall be formed, drilled, or neatly cut.
 - c. The Contractor shall use brick, masonry block, other standard masonry units, and sound local stone in conjunction with mortar to fill the void between the pipe culverts and the precast drainage structures. Stone or masonry units, areas of the pipe openings, and exterior walls of pipe shall be thoroughly wetted and then bonded with mortar by standard masonry practice in such a manner as to provide a contiguous masonry connection between the precast drainage structures and the pipe culverts. The remaining exterior and interior voids shall be filled with mortar and shaped to the contour of the precast structure.
 - d. When precast units are to be located adjacent to the subbase or base course, units with chambers shall be provided with weep holes 3 inches in diameter and hardware cloth and shall be located to drain the subbase or base.
 - e. Precast units located adjacent to cast-in-place concrete items, such as flumes, ditches, and gutters, shall be connected to the adjacent unit by means of No. 4 smooth steel dowels spaced on approximately 12-inch centers throughout the contact length and extending at least 4 inches into both the precast unit and the cast-in-place item. If holes to receive the dowels are provided in the precast unit, they shall be not more than 5/8 inch in diameter. Other methods of providing the con-

nection, such as keyed joints, shall be approved by the Engineer prior to fabrication.

- f. The chamber section shall be installed in the plumb position. The throat and top sections shall have positive restraints, such as adjacent concrete, pavement, or soil, on all sides to prevent displacement and shall have a positive interlock, such as dowels, with the chamber section. The throat and top sections shall be installed to conform with the normal slope of the finished grade and may be canted up to a maximum grade of 10 percent. The chamber may be built up to a maximum of 12 inches at any point to provide for complete and uniform bearing of the throat and top sections on the chamber flat slab top or other approved top section. The built-up section shall be constructed using whole concrete spacer units where feasible and partial and whole sections of concrete block or brick with high-strength grout and mortar. High-strength grout shall be used to provide the final grade adjustment and uniform bearing. The width of the built-up section shall match the wall thickness of the chamber section. The concrete block and brick shall be thoroughly bonded with mortar, and the inside and outside of the built-up section shall be plastered with mortar except that the concrete spacer unit shall not be plastered.

2. **Precast arches** shall conform to the applicable requirements of AASHTO's *Standard Specifications for Highway Bridges* with the following modifications:

- a. **Combination of loads:** For service load design: E: vertical loads: 1.00; lateral loads: 1.00 and 0.5 (check both loadings).

For load factor design: E: vertical loads: 1.00; lateral loads: 1.30 and 0.5 (check both loadings).

- b. **Protection against corrosion:** The concrete cover of reinforcement shall be at least 1 1/2 inches.

In corrosive or marine environments or other severe exposure conditions, reinforcement shall be epoxy coated in accordance with the requirements of Section 223.

Exposed reinforcing bars, inserts, and plates intended for bonding with future extensions shall be protected from corrosion as directed by the Engineer.

Reinforcement shall be designed and detailed in consideration of fabrication and construction tolerances so that the minimum required cover and proper positioning of reinforcement shall be maintained.

- c. **Anchorage:** Sufficient anchorage shall be provided at the terminus of lines of precast units. Anchorage may consist of a cast-in-place end section at least 3 feet in length with a headwall or collar around the precast unit(s) provided adequate connection can be made between the collar and units.
- d. **Joints:** Joints between units shall be sealed by preformed plastic or mastic gaskets or grout. When preformed gaskets are used, they shall be of a type listed on the Department's approved products list.

- e. **Pipe openings:** Pipe openings will not be allowed in the precast arch but may be provided through the wingwalls. When required, openings shall conform to the requirements of (b)1.b. herein.
3. **Precast box culverts** shall conform to the applicable requirements of AASHTO M 259 or M 273 and AASHTO's *Standard Specifications for Highway Bridges* with the following modifications:
- a. The combination of loads shall be as follows: For service load design or load factor design: E: new reinforced concrete boxes: vertical loads: 1.00; lateral loads: 1.00 and 0.5 (check both loadings).
 - b. For protection against corrosion, the following minimum concrete cover shall be provided for reinforcement: For boxes with more than 2 feet of fill over the top slab: 1 1/2 inches. For boxes with less than 2 feet of fill over the top slab: top reinforcement of top slab: 2 1/2 inches; bottom reinforcement of top slab: 2 inches; all other reinforcement: 1 1/2 inches.

The minimum cover for reinforcement may be reduced by not more than 1/2 inch provided the reinforcement having reduced cover is epoxy coated or the concrete surfaces adjacent to the reinforcement are coated in accordance with the requirements of Section 416.

Reinforcing steel for box culverts used in 0 to 2 foot fills, used in corrosive or marine environments, or used in other severe exposure conditions shall be epoxy coated. When epoxy-coated reinforcing steel is required due to these conditions, the minimum cover specified shall not be reduced.

- c. The type of sealant used in joints between units shall be from the Department's Approved List of Preformed Plastic or Mastic Gaskets.

Where double or greater lines of precast units are used, a buffer zone of 3 to 6 inches between lines shall be provided. This buffer zone shall be backfilled with porous backfill conforming to the requirements of Section 204. The porous backfill shall be drained by a 3-inch-diameter weep hole, formed by non-rigid tubing, located at the top of the bottom haunch, centered in the outlet end section and at approximately 50-foot intervals along the length of the box. Weep holes shall be covered with a 3-foot-square section of filter barrier cloth firmly attached to the outside of the box. A 3-foot width of filter barrier cloth shall also be centered over the buffer zone for the entire length of the structure after placement of the porous backfill material. Filter barrier cloth shall conform to the requirements of Section 245.

Forming weep holes and furnishing and placing of the filter barrier cloth shall be included in the price bid per linear foot for the precast box culvert.

- d. At the terminus of precast units, sufficient anchorage shall be provided. This anchorage may consist of a cast-in-place end section at least 3 feet in length with a headwall and curtain wall or a collar cast-in-place around the units provided adequate connection can be made between the collar and units.

When the ends of precast units are skewed, the end section shall be cast monolithically. The skew may be provided by forming, saw cutting, or other methods approved by the Engineer. Regardless of the method used, the variation in the precast unit from the exact skew shall be not greater than 1 1/2 inches at any point.

- e. Pipe openings shall conform to the requirements of 1.b. herein.
 - f. Bedding and backfill shall be in accordance with Standard PB-1 for box culverts.
- (c) **Drop Inlets, Manholes, Junction Boxes, Spring Boxes, Intake Boxes, and Endwalls:** Masonry construction shall not be initiated when the air temperature is below 40 degrees F in the shade.

The foundation shall be explored below the bottom of the excavation to determine the type and condition of the foundation. Foundation exploration shall extend to a depth equal to 1/2 inch per foot of fill height or 8 inches, whichever is greater. The Contractor shall report the findings of the foundation exploration to the Engineer for approval prior to placing structure.

Where unsuitable foundation is encountered at the established grade, as determined by the Engineer, such material shall be removed and replaced.

Backfill for areas where unsuitable material has been removed shall be placed and compacted in accordance with the requirements of Section 303.04(g).

Bedding material shall be placed in accordance with the Standard Drawings and shall be aggregate No. 25 or 26 conforming to the requirements of Section 205 except where standing or running water is present in the foundation excavation; then, bedding material shall be aggregate No. 57 for the depth specified on the plans or as directed by the Engineer capped with 4 inches of aggregate No. 25 or 26. Where such conditions are discovered in the field and the Contractor is directed by the Engineer to use No. 57 stone, No. 57 stone will be paid for at the existing contract unit price or, if not in the Contract, in accordance with Section 109.05.

Bedding shall be lightly and uniformly compacted. The depth of bedding material shall be as specified on the standard drawings or in the plans.

Brick and concrete block masonry shall be placed so that each unit will be thoroughly bonded with mortar. Joints shall be full-mortar joints not more than 1/2 inch in width. Where brick masonry is used, headers and stretchers shall be arranged to bond the mass fully. Every seventh course shall be placed entirely with headers. Inside joints shall be neatly pointed, and the outside of such walls shall be plastered with mortar as they are placed.

Iron fittings entering the masonry shall be placed as the work is built up, thoroughly bonded, and accurately spaced and aligned.

Inlet and outlet pipe connections shall conform to the same requirements as the pipe to which they connect and shall be of the same size and kind. Pipe sections shall be flush on the inside of the structure wall and shall project outside sufficiently for proper connection with the next pipe section. Masonry shall fit neatly and tightly around the pipe.

Immediately following finishing operations, hydraulic cement concrete shall be cured and protected in accordance with the requirements of Section 316.04(j).

Backfilling shall be performed in accordance with the requirements of Section 303.04(g). Surplus material shall be removed, and the site shall be left in a neat and orderly condition.

When grade adjustment of existing structures is specified, frames, covers, and gratings shall be removed and the walls shall be reconstructed as required. Cleaned frames shall be reset at the required elevation. Upon completion, each structure shall be cleaned of silt, debris, and foreign matter and shall be kept clear of such accumulation until final acceptance.

302.04—Measurement and Payment

Pipe culverts will be measured in linear feet. The quantity will be determined by counting the number of sections and multiplying by the length of the section used. When a partial section is required, the actual length of the partial section will be measured in place.

Structural plate pipe and pipe arches will be measured in linear feet along the invert line.

Pipe tees and elbows will be measured in linear feet of pipe.

Pipe reducers will be measured in linear feet of pipe for payment at the larger pipe size.

Pipe shall be paid for at the contract unit price per linear foot. This price shall include excavating, when not paid for as minor structure excavation; sheeting; shoring; dewatering; disposing of surplus and unsuitable material; and restoring existing surfaces. The upper 4 inches of bedding material and the Class I backfill material within the neat lines shown for each foundation type on the Standard PB-1 drawings shall be included in the price for the related pipe. When unit prices for extended pipelines are not specified, the unit price for new pipe of the same size shall apply. When not a pay item, the cost of the temporary relocation of a stream to facilitate the installation of the pipe shall be included in the price for the pipe. The cost of fittings, anti-seepage collars, and anchor blocks shall be included in the price for the pipe.

Jacked and bored pipe will be measured in linear feet to the nearest 1/10 of a foot along the centerline of completed jacked and bored pipe for the size indicated and will be paid for at the contract unit price per linear foot. This price shall include excavating and backfilling jacking and receiving pits, sheeting, shoring, bracing, jacking equipment, casing pipe, casing chocks, furnishing and installing carrier pipe, grout to install carrier pipe, drainage, safety equipment, and all other items necessary for this operation,

Tunneled pipe will be measured in linear feet to the nearest 1/10 of a foot along the centerline of completed tunnel for the size of lining and will be paid for at the contract unit price per linear foot. This item shall include equipment, materials, handling and disposal of all materials encountered, drainage, pumping and dewatering, tunnel support, lining, furnishing and installing pipe, grouting, ventilation, lighting and wiring, coordination and planning with the railroad or other specified entity, and all other appurtenances necessary to complete the work.

Reinstalled pipe will be measured in linear feet along a line parallel to the flow line and will be paid for at the contract unit price per linear foot of pipe and per cubic yard of minor structure excavation. This price shall include excavation involved in removing pipe, hauling, cleaning, relaying, backfill-

ing, necessary cutting for joining to other sections of pipe, furnishing new coupling bands, disposing of surplus excavation, and replacing any otherwise usable sections damaged or broken because of the negligence of the Contractor.

End sections and pipe spillouts will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each.

Endwalls and arch substructures will be measured in cubic yards of concrete and pounds of reinforcing steel except that EW-12 endwalls will be measured in units of each, complete-in-place. Endwalls and arch substructures will be paid for at the contract unit price per cubic yard of miscellaneous concrete and per pound of reinforcing steel except that crack control bars shall be included in the price bid for miscellaneous concrete and Standard EW-12 endwalls will be paid for at the contract unit price per each.

Minor structure excavation will be measured and paid for in accordance with the requirements of Section 303.06.

Cast-in-place box culverts will be measured in cubic yards of concrete and pounds of reinforcing steel and will be paid for at the contract unit price per cubic yard of concrete and per pound of reinforcing steel. These prices shall include excavating, sheeting, shoring, dewatering, waterproofing, disposing of surplus and unsuitable material, restoring existing surfaces, the upper 6 inches of bedding material within the neat lines shown on the Standard PB-1 drawings, and all necessary work to key the bottom slab into an existing rock foundation. When not a pay item, the cost of the temporary relocation of a stream to facilitate the installation of the structure shall be included in the price for the concrete and steel.

If the Contractor elects to furnish and install precast box culverts or precast arches, payment will be made for the original quantities shown on the plans for cast-in-place units. No additional compensation will be made for casting, prestressing, or shipping precast units or performing additional work, such as waterproofing, epoxy coating, or joint sealing, required as a result of the substitution.

Precast box culverts will be measured in linear feet along the centerline of the barrel from face of curtain wall to face of curtain wall and will be paid for at the contract unit price per linear foot. This price shall include designing, casting, reinforcing, excavating, sheeting, shoring, dewatering, installing, waterproofing, sealing joints, anchoring, disposing of surplus and unsuitable material, restoring existing surfaces, the upper 6 inches of bedding material within the neat lines shown on the Standard PB-1 drawings, fittings, and providing buffer zones and porous backfill for multiple lines. When not a pay item, the cost of the temporary relocation of a stream to facilitate the installation of the structure shall be included in the price for the box culvert.

If the Contractor elects to furnish and install precast box culverts or precast arches, payment will be made for the original quantities shown on the plans for cast-in-place units. No additional compensation will be made for casting, prestressing, or shipping precast units or performing additional work, such as waterproofing, epoxy coating, or joint sealing, required as a result of the substitution.

Grates and frames will be measured in units of each and will be paid for at the contract unit price per each.

Pipe grate will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include fabricating, furnishing, galvanizing, and installing.

Drop inlets and intake boxes will be measured as complete units, including the frame and grate or cover, and will be paid for at the contract unit price per each. The contract unit price for drop inlets will be adjusted at the rate of 5 percent per foot for increases or decreases in the depth indicated on the plans except that no adjustment will be made for changes amounting to less than 6 inches in the height of a single drop inlet. Where curb or curb and gutter extend along the drop inlet, the contract unit price for drop inlets shall include that part of the curb or gutter within the limits of the structure. Bedding material, except aggregate No. 57, will be included in the price of the structure.

Base sections of pipe tee units used as drop inlets and manholes will be measured in linear feet horizontally and will be paid for at the contract unit price per linear foot of pipe specified. The riser section and additional costs for the tee shall be included in the price for the drop inlet or manhole.

Manholes will be measured in linear feet, vertical measure, from top of foundation slab to top of masonry on which the casting frame is placed. However, when manholes are constructed as tee sections, measurement will be made to the pay limits shown on the plans. Manholes will be paid for at the contract unit price per vertical linear foot exclusive of frame and cover. Bedding material, except aggregate No. 57, will be included in the unit price per foot for the manhole.

Concrete spring boxes will be measured in cubic yards of concrete, pounds of reinforcing steel, and linear feet of pipe and will be paid for at the contract unit price per cubic yard of concrete, per pound of reinforcing steel, and per linear foot of pipe.

Junction boxes will be measured in cubic yards of concrete, pounds of reinforcing steel, pounds of structural steel, and each complete frame and cover assembly and will be paid for at the contract unit price per cubic yard of concrete, per pound of reinforcing steel, per pound of structural steel, and per each frame and cover assembly. Bedding material, except aggregate No. 57, will be included in the price of the structure.

Casting frames and covers will be measured in units of one complete frame and cover and will be paid for at the contract unit price per each.

Reconstructed manholes will be measured as a complete unit and will be paid for at the contract unit price per each.

Precast arches will be measured in linear feet along the centerline of the invert from face of headwall to face of headwall. When a pay item, precast arches will be paid for at the contract unit price per linear foot. This price shall include designing, forming, casting, reinforcing, excavating, wingwalls, installing, waterproofing, sealing joints, anchoring and bedding, and providing buffer zones for multiple lines. The cost for cast-in-place work other than that specified on the plans shall be included in the price for precast arches.

Temporary diversion channel lining will be measured in square yards for the class specified and will be paid for at the contract unit price per square yard. This price shall include installing the channel lining and removal when no longer required.

Temporary diversion channel excavation will be measured in cubic yards and will be paid for at the contract unit price per cubic yard. This price shall include excavation, temporary pipe culverts, removal of pipe culverts when no longer required, backfilling, and site restoration including regrading and seeding.

Excavation, backfill, and disposal of unsuitable or surplus material for drop inlets, intake boxes, manholes both new and reconstructed, spring boxes, junction boxes, and base sections of pipe tee units used as drop inlets and manholes will not be measured for separate payment, and the cost thereof shall be included in the bid price for such items. In the event steps or invert shaping is required, the cost thereof shall also be included in the price for such items.

Storm water management drainage structure will be measured in linear feet, vertical measure, from top of concrete foundation to the top of the concrete cover. The price bid shall include Class A3 concrete; reinforcing steel; trash rack; debris rack; orifice; steps; steel plate; and, when required, polyethylene tubing, pipe hangers, and steel pipe.

Temporary sediment riser pipe will be measured in linear feet for the size specified and will be paid for at the contract unit price per linear foot. The price shall include the riser pipe, steel plate, perforated pipe, debris rack, orifice and Class A1 riprap, and anti-vortex device when required.

Storm water management dam will be measured and paid for at the contract unit price per cubic yard of concrete and pound of reinforcing steel.

Payment will be made under:

Pay Item	Pay Unit
Pipe (Size and type)	Linear foot
Structural plate arch (Size)	Linear foot
Jacked and bored pipe (Size)	Linear foot
Tunneled pipe (Size)	Linear foot
Reinstalled pipe	Linear foot
End section (Standard and size)	Each
Pipe spillout (Standard)	Each
Concrete (Class)	Cubic yard
Reinforcing steel	Pound
Endwall grate and frame (Standard)	Each
Precast box culvert (Size)	Linear foot
Endwall pipe grate (Type)	Linear foot
Drop inlet (Standard and length)	Each
Intake box (Standard)	Each
Structural steel (Type)	Pound
Manhole (Standard)	Linear foot
Frame and cover (Standard)	Each
Reconstructed manhole	Each
Precast arch (Size)	Linear foot
Temporary diversion channel lining (Class)	Square yard
Temporary diversion channel excavation	Cubic yard
Endwall, Standard EW-12	Each
Storm water management drainage structure (Type)	Linear foot
Temporary sediment riser pipe (Size)	Linear foot

SECTION 303—EARTHWORK

303.01—Description

This work shall consist of constructing roadway earthwork in accordance with these specifications and in conformity with the specified tolerances for the lines, grades, typical sections, and cross sections shown on the plans or as established by the Engineer. Earthwork shall include regular, borrow, undercut, and minor structure excavation; constructing embankments; disposing of surplus and unsuitable material; shaping; compaction; sloping; dressing; and temporary erosion and siltation control work.

303.02—Materials

- (a) **Borrow excavation** shall consist of approved material required for the construction of the roadway and shall be obtained from approved sources outside the project limits. Borrow excavation shall conform to the requirements of AASHTO M57 and the requirements herein.
- (b) **Materials for temporary silt fences, geotextile fabric silt barriers, and filter barriers** shall conform to the requirements of Sections 242.02(c) and 245.03(a).
- (c) **Geotextile materials used for embankment stabilization** shall conform to the requirements of Section 245.03(e).
- (d) **Mulch** shall conform to the requirements of Section 244.02(g).

303.03—Erosion and Siltation Control

Erosion and siltation shall be controlled through the use of the devices and methods specified herein or as is otherwise necessary. The Engineer reserves the right to require other temporary measures not specifically described herein to correct an erosion or siltation condition.

Erosion and siltation control devices and measures shall be maintained in a functional condition at all times. Temporary and permanent erosion and siltation control measures shall be inspected after each rainfall and at least daily during periods of prolonged rainfall. Deficiencies shall be immediately corrected. The Contractor shall make a daily review of the location of silt fences and filter barriers to ensure that they are properly located for effectiveness. Where deficiencies exist, corrections shall be made immediately as approved or directed by the Engineer.

When erosion and siltation control devices function by using wet storage, sediments shall be removed when the wet storage volume has been reduced by 50 percent. Sediments shall be removed from dewatering basins when the excavated volume has been reduced by 50 percent. Sediments shall be removed from all other erosion and siltation control devices when capacity, height, or depth has been reduced by 50 percent. Removed sediment shall be disposed of in accordance with the requirements of Section 106.04 Sediment deposits remaining in place after the device is no longer required shall be dressed to conform with the existing grade, prepared, and seeded in accordance with the requirements of Section 603.

Geotextile fabric that has decomposed or has become ineffective and is still needed shall be replaced. Temporary erosion and sediment control devices except brush silt barriers shall be removed within 30 days after final site stabilization or after the temporary devices are no longer needed as determined by the Engineer.

- (a) **Earth Berms and Slope Drains:** The top of earthwork shall be shaped to permit runoff of rainwater. Temporary earth berms shall be constructed and compacted along the top edges of embankments to intercept runoff water. Temporary Berms and temporary dikes are to be stabilized immediately following installation. Temporary slope drains shall be provided to intercept runoff and adequately secured to prevent movement. Slope drains may be flexible or rigid but shall be capable of being readily shortened or extended. A portable flume shall be provided at the entrance to temporary slope drains.
- (b) **Soil Stabilization:** Soil stabilization shall be applied within 7 days after attaining the appropriate grading increment for that stage of the construction operations, or upon suspension of grading operations for an anticipated duration of greater than 15 days, or upon completion of grading operation for a specific area. Areas excluded from this requirement include areas within 100 feet of the limits of ordinary high water or a delineated wetland which shall be continuously prosecuted until completed and stabilized immediately upon completion of the work in each impacted area. Soil stabilization includes: temporary and permanent seeding, riprap, aggregate, sod, mulching, and soil stabilization blankets and matting in conjunction with seeding. The applicable type of soil stabilization shall depend upon the location of areas requiring stabilization, time of year (season), weather conditions and stage of construction operations.

Cut and fill slopes shall be shaped and topsoiled where specified. Seed and mulch shall be applied in accordance with the requirements of Section 603 as the work progresses in the following sequence:

1. Slopes whose vertical height is 20 feet or greater shall be seeded in three equal increments of height. Slopes whose vertical height is more than 75 feet shall be seeded in 25-foot increments.
2. Slopes whose vertical height is less than 20 but more than 5 feet shall be seeded in two equal increments.
3. Slopes whose vertical height is 5 feet or less may be seeded in one operation.

Areas that cannot be seeded because of seasonal or adverse weather conditions should be mulched to provide some protection against erosion to the soil surface. Organic mulch shall be used, and the area then seeded as soon as weather or seasonal conditions permit in accordance with the requirements of Section 303.03(e). Mulch shall be applied in accordance with the requirements of Section 603.04. Organic mulch includes: straw or hay, fiber mulch, wood cellulose, or wood chips conforming to the requirements of Section 244.02(g).

- (c) **Check Dams:** As an initial item of work, required check dams shall be constructed at 25-foot intervals, unless otherwise shown on the plans, below the outfall end of drainage structures.

Synthetic check dams recorded in the Department's Approved List may be substituted for Standard EC-4, Rock Check Dams, Type II, with the approval of the Engineer at no addi-

tional cost to the Department. Synthetic check dams shall be installed in accordance with the manufacturer's recommendation.

- (d) **Baled Straw Silt Barriers:** Baled straw silt barriers may be substituted for temporary filter barriers with the approval of the Engineer in noncritical areas, such as pavement areas and rock locations where filter barriers cannot be installed in accordance with the plans and specifications and locations where the Engineer determines that streams and water beds will not be affected.
- (e) **Temporary Silt Fences, Geotextile Fabric Silt Barriers, and Filter Barriers:**

1. **Temporary silt fences:** Fences shall be erected at locations shown on the plans or determined by the Engineer. Geotextile fabric used for silt fences shall be provided, and posts shall not be spaced more than 6 feet apart. Posts shall be uniformly installed with an inclination toward the potential silt load area of at least 2 degrees but not more than 20 degrees. Attaching fabric to existing trees will not be permitted.

Fabric shall be firmly secured to the post or wire fence. The bottom of the fabric shall be entrenched in the ground in a minimum 6-inch by 6-inch trench. Temporary silt fence may also be entrenched using a slicing method with a minimum of 8 inches sliced into the ground. Fabric may be spliced only at support posts and with an overlap of at least 6 inches. The top shall be installed with a 1-inch tuck or reinforced top end section. The height of the finished fence shall be a nominal 29 inches.

2. **Geotextile fabric silt barriers:** Existing fences or brush barriers used along the downhill side of the toe of fills shall have geotextile fabric attached at specified locations as shown on the plans. The bottom of the fabric shall be entrenched in the ground in a minimum 6-inch by 6-inch trench, and the top shall be installed with a 1-inch tuck or reinforced top end section. Temporary fabric silt barriers may also be entrenched using a slicing method with a minimum of 8 inches sliced into the ground.

Brush barriers shall be installed prior to any major earth-disturbing activity and trimmed sufficiently to prevent tearing or puncturing fabric. Fabric shall be fastened securely to the brush barrier or existing fence. A 6-inch overlap of fabric for vertical and horizontal splicing shall be maintained and tightly sealed.

3. **Temporary filter barriers:** Barriers shall consist of geotextile fabric and shall be securely fastened to wood or metal supports that are spaced at not more than 3-foot intervals and driven at least 12 inches into the ground. At least three supports shall be used. The bottom of the fabric shall be entrenched in the existing ground in a minimum 4-inch by 4-inch trench.

Temporary filter barriers may also be entrenched using a slicing method with a minimum of 6 inches sliced into the ground. The top of the fabric shall be installed with a 1-inch tuck or reinforced top end section. The height of the finished temporary filter barrier shall be a nominal 15 inches.

Temporary filter barriers shall be installed at temporary locations where construction changes the earth contour and drainage runoff as directed or approved by the Engineer.

After removal and disposal of the temporary silt fence, geotextile fabric silt barrier, and temporary filter barrier, the area shall be dressed and stabilized with a permanent vegetative cover or other approved permanent stabilization practice approved by the Engineer.

- (f) **Sediment Traps and Sediment Basins:** Sediment traps are required if storm water runoff from less than 3 acres flows across a disturbed area of 10,000 square feet or more. Sediment basins are required if storm water runoff from 3 or more acres flows across a disturbed area of 10,000 square feet or more. Once a sediment trap or basin is constructed, the dam and all outfall areas shall be stabilized immediately.
- (g) **Erosion Control Mulch:** This work shall consist of furnishing and applying mulch as a temporary erosion control treatment on slopes exposed to the elements but not at final grade during the period from December 1 to March 1 for periods of up to 30 days prior to final grading or to areas to receive stabilization or paved surfaces within 6 months in accordance with this provision and as directed by the Engineer.

Mulch shall be applied to exposed slopes requiring mulch or to areas to be stabilized or paved, within 48 hours after performance of grading operations. Straw or hay mulch shall be applied on bare slope areas at the rate of approximately 3 tons per acre (1.24 pounds per square yard). Straw or hay mulch shall be applied at a uniform thickness in such a manner that not more than 10 percent of the soil surface will be exposed. Straw or hay mulch shall be anchored to the slope surface by one of the following methods: spraying with cellulose fiber mulch at the rate of 750 pounds per acre (0.15 pound per square yard); disking or punching the mulch partially into the soil; using approved netting; or using other materials or methods approved by the Engineer. The Contractor may use more than one method on the same project.

303.04—Procedures

Loose rock 3 inches or larger shall be removed from the surface of cut slopes.

When slides occur, the Contractor shall remove and dispose of material as directed by the Engineer.

Where required, surface ditches shall be placed at the top of cut slopes or at the foot of fill slopes and at such other points not necessarily confined to the right of way or shown on the plans and shall be of such dimensions and grades as directed by the Engineer.

Allaying dust, when specified, shall be performed in accordance with the requirements of Section 511.

Prior to the beginning of grading operations in the area, necessary clearing and grubbing shall be performed in accordance with the requirements of Section 301.02.

- (a) **Regular Excavation:** Existing foundations and slabs located within the construction limits shall be removed and disposed of in a location approved by the Engineer. In lieu of removal, foundations and slabs located 5 feet or more below the proposed subgrade may be broken into particles not more than 18 inches in any dimension and reoriented to break the shear plane and allow for drainage.

Cisterns, septic tanks, wells, and other such structures shall be cleared in accordance with the requirements of Section 516.

Balance points shown on the plans are theoretical and may vary because of actual field conditions.

When the material to be excavated necessitates the use of explosives, the requirements of Section 107.11 relating to the use of explosives shall apply. To prevent damage to newly constructed concrete, the Contractor shall schedule blasting operations in the proximity of proposed concrete structures so that work will be completed prior to placement of concrete.

Regular excavation shall consist of removing and disposing of material located within the project limits, including widening cuts and shaping slopes necessary for preparing the roadbed; removing root mat; stripping topsoil; cutting ditches, channels, waterways, and entrances; and performing other work incidental thereto. The Engineer may require materials in existing pavement structures to be salvaged for use in traffic maintenance.

Undrained areas shall not be left in the surface of the roadway. Grading operations shall be conducted so that material outside construction limits will not be disturbed.

Where rock or boulders are encountered, the Contractor shall excavate and backfill in accordance with the plans and contract documents.

When the presplitting method of excavation is specified for rock cuts, work shall be performed in a manner to produce a uniform plane of rupture in the rock and so that the resulting backslope face will be unaffected by subsequent blasting and excavation operations within the section. Rock shall be presplit along rock slopes at locations, lines, and inclinations shown on the plans or as determined by field conditions. A test section shall be provided to establish the spacing of drill holes and the proper blasting charge to be used in the presplitting operation. Drill holes shall be spaced not more than 3 feet apart and shall extend to the plan grade or in lifts of not more than 25 feet, whichever is less. If drilled in benches, an offset may accommodate the head of the drill, but no offset shall be more than 12 inches. Presplitting shall extend at least 20 feet ahead of the limits of fragmentation blasting within the section.

Where the project has been designed and slopes have been staked on the assumption that solid rock will be encountered and the Contractor fails to encounter solid rock at the depth indicated, he shall cease excavation in the area and immediately notify the Engineer. If it is necessary to redesign and restake slopes, any additional excavation necessary will be paid for at the contract unit price per cubic yard.

Topsoil stockpiled for later use in the work shall be stored within the right of way unless the working area is such that the presence of the material would interfere with orderly prosecution of the work. Stockpile areas outside the right of way shall be located by the Contractor at his expense. Topsoil used in the work shall be removed first from stockpiles located on private property. Surplus topsoil remaining on private property after completion of topsoiling operations shall be moved onto the right of way and stockpiled, shaped, and seeded as directed by the Engineer.

Stripping topsoil shall be confined to the area over which grading is to be actively prosecuted within 15 calendar days following the stripping operation. Grading operations shall be

confined to the minimum area necessary to accommodate the Contractor's equipment and work force engaged in the earth moving work.

- (b) **Borrow Excavation:** The Contractor shall make his own arrangements for obtaining borrow and pay all costs involved in accordance with the provisions of Section 106.03.

If the Contractor places an excess of borrow and thereby causes a waste of regular excavation, the amount of such waste, unless authorized, will be deducted from the volume of borrow as measured at the source or computed by vehicle count as specified in Section 109.01.

When borrow is obtained from sources within the right of way and the excavation is performed simultaneously with regular excavation, borrow excavation will be designated as regular excavation. Material secured by widening cuts beyond slope stakes, when taken from previously excavated slopes, will be designated as borrow excavation. When such a procedure is approved, slopes shall be uniform and no steeper than shown on the plans.

Borrow excavation areas shall be bladed and left in a shape to permit accurate measurements after excavation has been completed.

CBR values, stipulated for borrow excavation, shall apply to the uppermost three feet of fill below the top of earthwork, as defined in Section 101 of the Specifications. Borrow excavation, installed below the top three feet shall consist of suitable fill material, available from regular excavation or borrow excavation, as defined and of a quality consistent with project requirements.

- (c) **Undercut Excavation:** Undercut excavation shall consist of removing and disposing of unsuitable material located within the construction limits in accordance with the requirements of Section 303.06(a)3.

Undercut excavation shall be disposed of in accordance with the requirements of Section 106.04.

- (d) **Minor Structure Excavation:** Minor structure excavation shall consist of removing material necessary to accommodate the structure, such as box or arch culverts, including pipe arches, structural plate arches, structural plate pipe, pipe culverts, and storm drains with a span(s) or opening(s) of 48 inches or greater. Minor structure excavation shall also include dewatering, sheeting, bracing, removing existing structures, and backfilling. Removing existing structures shall also include foundations that might be necessary to clear the site.
- (e) **Removing Unsuitable Material:** Where excavation to the finished graded section results in a subgrade or slopes of unsuitable material, such material shall be excavated below the grade shown on the plans or as directed by the Engineer. Areas so excavated shall be back-filled with approved material in accordance with (f) herein.

Excavation for structures shall be carried to foundation materials satisfactory to the Engineer regardless of the elevation shown on the plans. If foundation material is rock, the Contractor shall expose solid rock and prepare it in horizontal beds for receiving the structure. Loose or disintegrated rock and thin strata shall be removed. Excavated material, if suitable, shall be used for backfilling around the structure or constructing embankments.

Material shown on the plans as unsuitable and during construction found to be suitable for use shall first be used in embankments where needed in lieu of borrow. However, the use of this material in lieu of borrow shall not alter the provisions of Section 104.02 regarding underruns.

Material shown on the plans as suitable material but found at time of construction to be unsuitable shall be disposed of as unsuitable material.

Unsuitable material shall be disposed of in accordance with Section 106.04.

- (f) **Backfill for Replacing Undercut Excavation:** Backfill shall be composed of regular excavation, borrow, select material, subbase material, or other material as directed by the Engineer. Backfilling operations shall be performed in accordance with (g) herein.
- (g) **Backfilling Openings Made for Structures:** Backfill shall be suitable material removed for the structure, although the Engineer may require that backfill material be obtained from a source within the construction limits entirely apart from the structure or other approved material. The opening to be backfilled shall be dewatered prior to backfilling. Backfill shall not be placed against or over cast-in-place box culverts or other structures until the top concrete slab section(s) has been in place 14 days, exclusive of days on which the average high-low ambient temperature is below 40 degrees F in the shade or until the concrete control cylinder(s) has attained a compressive strength equal to 93 percent of the 28-day design compressive strength.

Backfill shall be compacted in horizontal layers not more than 6 inches in thickness, loose measurement, and as specified in (h) herein. Backfill shall be placed in horizontal layers such that there will be a horizontal berm of compacted undisturbed material behind the structure for a distance at least equal to the remaining height of the structure or wall to be backfilled. Backfill shall be placed in a manner to deter impoundment of water and facilitate existing drainage. Backfill around piers in areas not included in the roadway prism shall be constructed in uniformly compacted layers. However, density requirements will be waived.

Box culverts shall not be opened to construction equipment traffic until concrete has attained 100 percent of the 28-day design compressive strength and has a backfill cover of at least 4.0 feet. The minimum height of backfill cover required to protect pipe culverts from construction equipment shall be in accordance with Standard Drawing PC-1 for the type and size specified.

Where only one side of abutments, wingwalls, piers, or culvert headwalls can be backfilled, care shall be taken that the area immediately adjacent to the structure is not compacted to the extent that it will cause overturning or excessive pressure against the structure. When both sides of a concrete wall or box structure is to be backfilled, operations shall be conducted so that the backfill is always at approximately the same elevation on both sides of the structure.

Openings subject to flooding shall be backfilled as soon as practicable or as directed by the Engineer.

- (h) **Embankments:** Work shall consist of constructing roadway embankments; placing and compacting approved material within roadway areas where unsuitable material has been re-

moved; and placing and compacting approved material in holes, pits, utility trenches, basements, and other depressions within the roadway area.

Embankment shall be constructed with approved material and placed so as to be uniformly compacted throughout. Embankment shall be placed adjacent to structures in the same manner as for backfill as described in (g) herein. Embankment shall not contain muck, frozen material, roots, sod, or other deleterious material. Embankment shall not be placed on frozen ground or areas covered with ice or snow.

Unsuitable material used in widening embankments and flattening embankment slopes shall be placed in uniform layers not more than 18 inches in thickness before compaction. Each layer of material placed shall be compacted to the extent necessary to produce stable and reasonably even slopes.

Wherever rock excavation is available on the project, an 8 to 15-inch layer of such materials shall be dump spread over the lower region of embankments in the immediate vicinity of stream crossings and used to cover ditches, channels, and other drainage ways leading away from cuts and fills. However, drainage ways shall be prepared to receive the rock excavation to the extent necessary to avoid reducing their cross section. If rock excavation is not available on the project, rip-rap, jute mesh or soil retention mats shall be used as the covering material and shall be installed in accordance with the requirements of Section 606.03(c). Limits of the area to be covered will be as noted on the plans or as directed by the Engineer.

Wherever sufficient right of way exists, surplus materials shall be used to widen embankments and flatten slopes as directed by the Engineer.

Rock excavation may be placed on slopes by uniform end dumping of the material from along the top of the embankment or as directed by the Engineer. Slopes that are covered with rock excavation shall not receive topsoil or seed.

When geotextile drainage fabric is required under rock fills, preparation shall be as specified in Section 245.

The Contractor shall schedule excavation and embankment work in a manner that will minimize the quantity of unsuitable material for which more than one handling is required prior to final placement. Therefore, the provisions for additional payment for each rehandling of material specified in Section 303.06(a) will not apply to placing unsuitable material for widening embankments and flattening embankment slopes.

The surface area directly beneath the pavement and shoulders on which embankments of less than 5 feet in depth are to be constructed shall be denuded of vegetation. These areas shall be scarified and compacted to a depth of 6 inches to the same degree as the material to be placed thereon.

Areas that contain material unsuitable as foundations for embankments shall be undercut and backfilled in accordance with (e) and (f) herein.

Embankments to be placed over saturated areas that will not support the weight of hauling equipment may be constructed by end dumping successive loads in a uniformly distributed layer of a thickness capable of supporting the hauling equipment while subsequent layers are placed. The nose, or leading edge, of the embankment shall be maintained in a wedge

shape to facilitate mud displacement in a manner that will prevent its entrapment in the embankment. The front slope of the embankment shall be maintained steeper than 2:1. The use of compacting equipment will not be required on the original course. However, the remainder of the embankment shall be constructed in layers and compacted in accordance with these specifications.

When geotextile for embankment stabilization is required, it shall be placed as shown on the plans. Geotextile shall be spliced by sewing double-stitched seams with stitching spaced 1/4 inch to 1/2 inch apart or as shown on the plans.

Once geotextile for embankment stabilization is placed, the initial lift of material to be placed atop shall be free draining and shall be end dumped onto the geotextile and spread to the thickness as shown on the plans. Free-draining material shall be any material of which 15 percent or less passes the No. 200 sieve. If the geotextile becomes punctured or torn, the Contractor shall repair the area with geotextile lapped at least 3 feet all around the damaged area.

When embankment is to be placed and compacted on an existing road, the surface shall be scarified to such degree as will permit an ample bond between old and new material. Hydraulic cement concrete and asphalt concrete pavement structures within the proposed roadway prism shall be demolished in accordance with Section 508.02(a).

Existing slopes shall be continuously benched where embankments are constructed one-half width at a time; against slopes of existing embankments or hillsides; or across existing embankments, hillsides, and depressions at a skew angle of 30 degrees or more or the existing slopes are steeper than 4:1. For slopes steeper than 4:1 but not steeper than 1-1/2:1, the bench shall be at least 6 feet in width. For slopes steeper than 1-1/2:1 but less than 1/2:1, the bench shall be at least 4 feet in width. Benching shall consist of a series of horizontal cuts beginning at the intersection with the original ground and continuing at each vertical intersection of the previous cut. Material removed during benching operations shall be placed and compacted as embankment material.

When excavated material consists predominantly of soil, embankment shall be placed in successive uniform layers not more than 8 inches in thickness before compaction over the entire roadbed area. Each layer shall be compacted within a tolerance of ± 20 percent of optimum moisture content to a density of at least 95 percent of the theoretical maximum density as defined in Section 101.02.

Material having a moisture content above optimum by more than 30 percent shall not be placed on a previously placed layer for drying unless it is shown that the layer will not become saturated by downward migration of moisture in the material.

Field density determinations will be performed in accordance with the requirements of AASHTO T191, modified to include material sizes used in the laboratory determination of density, with a portable nuclear field density testing device or by other approved methods. When a nuclear device is used, density determinations for embankment material will be related to the density of the same material tested in accordance with VTM-1 or VTM-12 and a control strip will not be required.

As the compaction of each layer progresses, continuous leveling and manipulating shall be performed to ensure uniform density. Prior to placement of subsequent layers, construction

equipment shall be routed uniformly over the entire surface of each layer or the layer shall be scarified to its full depth in the area where the equipment is routed.

When the excavated material consists predominantly of rock fragments of such size that the material cannot be placed in layers of the thickness prescribed without crushing, pulverizing, or further breaking down the pieces resulting from excavation methods, such material may be placed in the embankment in layers that are not thicker than the approximate average size of the larger rocks. Rock not more than 4 feet in its greatest dimension may be placed in an embankment to within 10 feet of the subgrade. The remainder of the embankment to within 2 feet of the subgrade shall not contain rock more than 2 feet in its greatest dimension. Each layer shall be constructed so that rock voids are filled with rock spalls, rock fines, and earth. Rock shall be placed, manipulated, and compacted in uniform layers. However, density requirements may be waived. Rock, rock spalls, rock fines, and earth shall be distributed throughout each embankment layer and manipulated as specified herein so that the voids are filled. Rock shall not be end dumped over the edges of the layer being constructed but shall be deposited on the layer and moved ahead so as to advance the layer with a mixture of rock, rock spalls, rock fines, and earth. The 2 feet of the embankment immediately below the subgrade shall be composed of material that can be placed in layers of not more than 8 inches before compaction and compacted as specified herein for embankments. Rock more than 3 inches in its greatest dimension shall not be placed within 12 inches of the subgrade in any embankment.

Rock, broken concrete, or other solid materials shall not be placed in embankment areas where piling is to be placed or driven.

The best material shall be reserved for finishing and dressing the surface of embankments. Work necessary to ensure the reservation of such material shall be the responsibility of the Contractor. Section 303.06(a) will not apply to subsequent handling of capping material.

CBR values, stipulated for Embankment, shall apply to the uppermost three feet of fill below the top of earthwork, as defined in Section 101 of the Specifications. Embankment, installed below the top three feet shall consist of suitable fill material, available from regular excavation, borrow excavation or embankment, as defined and of a quality consistent with project requirements.

Crushed glass shall be limited within the boundaries of the embankment as follows: Crushed glass shall be a minimum of two feet inside the side slope and contain a minimum of two feet of soil embankment cap. For those areas where crushed glass is to be incorporated into the embankment, glass may constitute up to approximately ninety percent by weight of that portion of the embankment, except where 100 percent crushed glass is used for drainage purposes (including blankets).

Crushed glass shall be blended with soil and/or soil like materials as follows:

1. The embankment shall be constructed by placing alternate four-inch layers of waste glass and soil and mixing and blending by scarification or other approved methods during compaction. The thickness of uncompacted layers of soil/glass shall be a maximum of 8 inches (loose); or
2. Pugmilled in predetermined ratios to a visually consistent blend and placed in lifts of a maximum of 8 inches (loose); or

3. As directed by the Engineer.

Compaction of the soil/glass embankment shall be to the satisfaction of the Engineer and shall be accomplished with a vibratory compactor or other approved methods. Moisture and density requirements for the soil/glass embankments shall be the same as other conventional soil embankment in accordance with the requirements of Section 303 of the Specifications.

Normal compaction procedures and requirements are to be used for compaction of the soil embankment "cap" above the crushed glass/soil blends.

(i) **Settlement Plates and Surcharge:** The Contractor shall expedite construction of embankment to provide the maximum time possible for settlement prior to completing grading operations.

1. **Settlement plates:** The base of settlement plates shall be firmly seated into original ground for the full depth of the steel fins. The base shall be leveled. The Engineer shall be provided time to obtain the elevation of the seated base and the top elevation of the pipe extensions prior to placement of embankment material. Pipe extensions shall not be more than 4 feet in length and shall be vertically installed as the embankment is constructed such that the top of the pipe is not covered. As each extension is added, the Engineer shall be provided time to obtain the top elevation of the existing pipe and the top elevation of the new pipe extension. Pipe extensions shall be properly flagged at all times. Care shall be taken while placing and compacting embankment material around pipe extensions. Settlement plates shall be maintained until no longer required, as determined by the Engineer. Upon completion of the normal embankment plus 2 feet of the specified surcharge, the Contractor shall immediately commence placing the remaining surcharge to the limits shown on the plans or as directed by the Engineer. The remaining surcharge shall be placed in lifts of not more than 1 foot in depth and compacted uniformly with construction hauling and spreading equipment. Each lift shall be completed over the entire surcharge area before the next lift is begun.

If a settlement plate is damaged, the Contractor shall notify the Engineer immediately and promptly repair it under the observation of the Engineer to the nearest undamaged pipe. Excavation, backfill, compaction, and repair of settlement plates shall be at the Contractor's expense. The Engineer shall be provided time to obtain the top elevation of the undamaged connection and the top elevation of each subsequent pipe extension.

Settlement plates shall remain in place until settlement has been completed as indicated by elevation readings taken by the Engineer at approximately 2-week intervals. Evaluation of the readings by the Engineer will be the final and sole governing factor for releasing embankments for grading operations. Upon written release by the Engineer, extensions of settlement plate pipe shall be removed to at least 2 feet below the subgrade, the pipe capped, and the area backfilled and compacted.

2. **Surcharge:** When authorized by the Engineer, surcharge shall be removed to the subgrade and embankment slopes graded to the typical section. Removed surcharge shall be placed in roadway embankments not previously brought to grade or shall be disposed of in accordance with Section 106.04 or as directed by the Engineer.

- (j) **Hydraulic Embankment:** Hydraulic embankment shall consist of dredging and pumping materials approved by the Engineer from designated areas, placing the material in embankments, and dressing and completing the embankment. Material shall be nonplastic and of such grading that not more than 7 percent will pass the No. 200 sieve.

Unless otherwise shown on the plans, material for the embankment shall not be obtained from sources closer than 300 feet from the toe of the slope of the embankment. The Engineer may reject materials considered to be unsatisfactory for use in the embankment, and such materials shall be stripped at the Contractor's expense before the embankment is built. Muck and unsuitable material shall be removed to the line, grade, and section shown on the plans. Unsatisfactory material brought to the top of the embankment shall be removed by the Contractor at his own expense, and satisfactory material shall be substituted.

In placing material in the embankment, the Contractor shall begin at the centerline and deposit material in either or both directions toward the toe of slopes. Discharge shall always be in the direction of and parallel with the centerline. The maximum distance from the bottom of the discharge pipe to the surface on which material is being deposited shall be 5 feet unless otherwise directed by the Engineer. Material shall be deposited in a manner that will maintain a higher elevation at the center of the roadway than on either side. The Contractor will not be permitted to construct retaining levees along the roadway of such dimensions as to cause damage to the foundation of the roadway. The Contractor shall conduct operations so as to ensure the completion of an embankment that will conform to the cross section shown on the plans except that he will be permitted to flatten side slopes. However, if material is deposited on private property, the Contractor shall obtain permission in writing from the affected property owner(s). No payment will be made for material beyond the limits of the net pay section.

The embankment shall be placed so as to ensure a minimum relative density of 80 percent of the theoretical maximum density when tested in accordance with (h) herein. If the method of placing the embankment fails to produce the required density, the Contractor shall use approved methods to obtain the specified density.

The Contractor shall take all necessary precautions to prevent placing material in streams. The Contractor shall be responsible for all damage to or caused by the hydraulic embankment. The Contractor shall provide sufficient material to maintain the embankment in accordance with the typical cross section as shown on the plans or as directed by the Engineer until final acceptance.

The Contractor's plan for support of suction or discharge pipes shall be submitted to and approved by the Engineer. Traffic shall be protected by the display of warning devices both day and night. If dredging operations damage an existing traveled highway, the Contractor shall cease operations and repair damage to the highway.

- (k) **Surplus Material:** Surplus material shall not be wasted or sold by the Contractor unless authorized in writing by the Engineer. When authorization has been given for surplus material to be wasted, it shall be disposed of in accordance with the requirements of Section 106.04.

Material shown on the plans as surplus material will not be considered for overhaul payment.

1. **Disposal of surplus material within the right of way where the haul distance is 2,000 feet or less:** Surplus material shall be used or disposed of where directed within a haul distance of 2,000 feet of its origin. Usage in this manner will not be considered a change in the character of the work.
2. **Disposal of surplus material within the right of way where the haul distance is more than 2,000 feet:** The Engineer reserves the right to require the Contractor to use surplus material in lieu of furnishing borrow, or as otherwise directed, where the haul distance from the origin of the material is more than 2,000 feet. Disposal of surplus material at locations requiring a haul of more than 2,000 feet will be considered a change in the character of work unless otherwise noted on the plans.

When material is declared surplus during construction and must be transported more than 2,000 feet from its origin, the Department will pay the Contractor \$0.03 per station per cubic yard for overhaul. The quantity of surplus excavation will be determined by vehicle measurement in accordance with the provisions of Section 109.01 or from cross-section measurements by the average end area method. The haul distance will be measured along a line parallel with the centerline of the roadway from the center of the excavated area to the center of the placement area. Overhaul will be the product of the quantity of surplus material in cubic yards and the haul distance in excess of 2,000 feet in 100-foot stations.

303.05—Tolerances

- (a) **Finished grade of subgrade** shall conform to the requirements of Section 305.03(c).
- (b) **Slopes** shall be graded in the following manner:
 1. **Earth excavation slopes:**
 - a. **Slopes steeper than 2:1** shall be grooved in accordance with the standard drawings and shall not deviate from the theoretical plane surface by more than 0.5 foot.
 - b. **Slopes steeper than 3:1 up to and including 2:1** shall be rough graded in a manner to provide horizontal ridges and grooves having no more than 0.5 foot deviation from the theoretical line of the typical cross section as is accomplished by the normal operation of heavy grading equipment.
 - c. **Slopes 3:1 or flatter** shall be uniformly finished and shall not deviate from the theoretical plane surface by more than 0.5 foot.
 2. **Earth embankment slopes:**
 - a. **Slopes steeper than 3:1** shall not deviate from the theoretical plane slope by more than 0.5 foot and shall be rough graded in a manner to provide horizontal ridges and grooves not more than 0.5 foot from the theoretical line of the typical cross section as is accomplished by the normal operation of heavy grading equipment.

- b. **Slopes 3:1 and flatter** shall be uniformly finished and shall not deviate from the theoretical plane surface by more than 0.5 foot.
3. **Rock slopes** shall not deviate from a plane surface by more than 2.0 feet and shall not deviate from their theoretical location by more than 2.0 feet measured along any line perpendicular to the theoretical slope line.

Finished excavation and embankment slopes shall not deviate from their theoretical location by more than 0.5 foot measured along any line perpendicular to the theoretical slope line.

303.06—Measurement and Payment

- (a) **Excavation:** Excavation will be paid for at the contract unit price per cubic yard unless otherwise specified.

Excavation requiring more than one handling prior to final placement will be paid for at the contract unit price for regular excavation for each handling approved by the Engineer unless there is a pay item for the second handling, in which case work will be paid for at the contract price for such handling.

Quantities of regular or borrow excavation used to backfill pipe, pipe culverts, and box culverts will not be deducted from quantities due the Contractor for payment.

- 1. **Regular excavation:** When payment is specified on a cubic yard basis, regular excavation will be measured in its original position by cross-sectioning the excavation area. This measurement will include overbreakage or slides not attributable to the carelessness of the Contractor and authorized excavation of rock, muck, root mat, or other unsuitable material except material included in undercut excavation. Volumes will be computed from cross-section measurements by the average end area method.

When it is impractical to measure material by the cross-section method, other acceptable methods involving three-dimensional measurements may be used.

Excavation for benching slopes to accommodate roadway embankments as specified in Section 303.04(h) will not be measured for separate payment. The cost thereof shall be included in the price for the related excavation or embankment item.

Excavation of existing roadways required to incorporate old roadway into new roadway or remove salvageable materials for use in traffic maintenance, other than those covered in Section 508, will be measured as regular excavation.

When “presplitting rock cuts” is shown on the plans, the work shall be considered incidental to the cost of excavation and will not be measured for separate payment.

In cut sections, excavation of topsoil and root mat and material down to a point 1 foot below the elevation of the top of earthwork or to the depth specified on the plans will be measured as regular excavation. When areas of unsuitable material are shown on the plans, excavation down to a point 1 foot below the elevation of such material shown on the plans will be measured as regular excavation.

In fill sections, excavation of topsoil and root mat and material down to an elevation of 1 foot below the bottom of topsoil and root mat will be measured as regular excavation. When areas of unsuitable material are shown on the plans, excavation down to a point 1 foot below the elevation of such material shown on the plans will be measured as regular excavation.

If slide material approved for measurement cannot be measured accurately, or if the removal of slide material will require different equipment than that being used in the regular excavation operations, payment therefor may be made on a force account basis when authorized by the Engineer.

Excavation of surface ditches specified on the plans or otherwise required by the Engineer will be paid for as regular excavation except that when required after the slopes have been completed and the work cannot be performed with mechanical equipment, the excavation will be paid for as undercut excavation.

2. **Borrow excavation:** Borrow excavation will be measured in its original position by cross-sectioning the area excavated. The number of cubic yards will be computed from cross-section measurements by the average end area method. When it is impractical to measure the borrow excavation, vehicular measurement in accordance with Section 109.01 may be used.

Borrow excavation with a stipulated CBR value shall be measured and paid for as borrow excavation with the CBR value as specified.

Borrow excavation without a stipulated CBR value shall be measured and paid for as borrow excavation.

3. **Undercut excavation:** Measurement will be made by cross-sectioning the undercut area. The number of cubic yards will be computed by the average end area method. When it is impractical to measure material by the cross-section method because of erratic location of isolated deposits, acceptable methods involving three-dimensional measurements may be used.

When unsuitable material must be removed from an area of the project where undercut is not shown on the plans, unsuitable material removed after reaching the depth specified in (a)1. herein, or 1 foot below original ground in fill sections where topsoil and root mat are not required to be removed, will be measured as undercut excavation.

Excavation of rock or unsuitable material below the elevation of the bottom of the lower theoretical slab or culvert thickness or below the excavation limits shown on the plans or standard drawings for normal earth foundations, whichever is the greater depth, of minor structures having a span(s) or opening(s) of less than 48 inches will be measured for payment as undercut excavation. Such excavation for structures having a span(s) or opening(s) of 48 inches or greater will be measured as minor structure excavation in accordance with (a)4. herein.

Undercut excavation will be paid for at the contract unit price per cubic yard. This price shall include removal and disposal. When not a pay item, undercut excavation will be paid for at twice the unit price per cubic yard for regular excavation.

4. **Minor structure excavation:** Excavation of material above the elevation of the bottom of the lower theoretical slab or culvert thickness, or above the excavation limits shown on the plans for earth foundations, whichever is the greater depth, for culverts having a maximum span or opening of less than 48 inches will not be measured for payment.

Excavation of material for culverts having a span(s) or opening(s) of 48 inches or greater and excavation for minor structures not covered elsewhere in these specifications will be measured in cubic yards of minor structure excavation. The quantity allowed for payment will be the actual volume of material removed as bounded by the bottom of the lower theoretical slab or culvert thickness, or lower excavation limits shown on the plans for earth foundations, whichever is the greater depth; the original ground or regular excavation pay line, whichever is the lower elevation; and vertical planes 18 inches outside the neat lines of the structure (excluding wingwalls and other appurtenances) or bound by vertical planes coincident with the applicable bedding excavation limits shown on the plans. Payment for excavation for wingwalls and other appurtenances to structures will be based on the ratio of the plan area of the wingwalls or appurtenances to the plan area of the barrel. Once the ratio has been determined, the pay quantity for minor structure excavation will be increased accordingly.

If embankment is placed prior to installation of a minor structure, excavation of the embankment area will not be measured for payment unless the Contract requires placement of the embankment prior to the installation of the minor structure.

The volume of the interiors of culverts, drop inlets, and other existing minor structures that must be removed will not be deducted from the overall quantity of minor structure excavation allowed for payment.

The price of minor structure excavation shall include the cost of backfill above the horizontal planes of the neatlines of the Class I or Class II backfill areas to original ground. Class I and Class II backfill shall be measured and paid for in accordance with Section 302.04.

5. **Earthwork:** When a pay item, earthwork will be paid for at the contract lump sum price, wherein no measurement will be made. This price shall include regular excavation, minor structure excavation, and grading.

(b) **Embankments:**

1. **If embankment is not a pay item,** the cost of embankment construction will be considered incidental to other items of excavation.
2. **If embankment is a pay item and regular excavation is to be paid for on a plan quantity basis,** the quantity of embankment for which payment will be made will not be measured separately but will be computed in accordance with the following:
 - a. The regular excavation plan quantity will be adjusted in accordance with (C) Plan Quantities herein.
 - b. The quantity of unsuitable material will be measured and subtracted from the adjusted regular excavation quantity determined in 2.a. herein. Quantities of unsuit-

able material removed from fill areas or below the subgrade in cut areas will be determined by using plan dimensions and may be adjusted for deviations based on actual measurement. Actual dimensions will be used to determine the quantity of any other unsuitable material.

- c. The total quantity shown on the plans will be adjusted for quantities not anticipated on the plans, such as changes in grade or undercut determined to be necessary during construction.
- d. The quantity of suitable material determined in 2.b. herein will be subtracted from the adjusted total fill quantity determined in 2.c. herein. The resultant quantity will be the embankment quantity for which payment will be made.

The Contractor shall be responsible for determining the effect of the shrinkage or swell factor of the material, and no adjustment will be made in pay quantities for this factor.

Hydraulic embankment will be paid for as embankment.

- 3. **If embankment is a pay item and regular excavation is to be paid for on the basis of measured quantities**, the quantity of embankment will be measured in cubic yards computed by the average end area method from the dimensions of the embankment cross section.

Cross sections of the area to be covered by the embankment will be taken after the denuding or removal of unsuitable material and before any material is placed thereon. These cross sections shall extend laterally from the centerline to the toes of slopes as indicated on the typical cross section. The elevations as determined by these sections will be considered the original ground line. The pay quantity to be measured will be the volume of material included in the section above the original ground and below the upper limits of the typical cross section.

When regular excavation is a pay item, the embankment area to be cross-sectioned will exclude that portion of the fill constructed from regular excavation. Material outside the limits of typical cross sections as shown on the plans will not be measured or paid for.

- 4. **Extra embankment required for subsurface consolidation** will be determined by the use of settlement plates. The total settlement recorded at each settlement plate will be allowed across 75 percent of the lateral width of each section. Volumes will be computed using the average end area method. Embankment quantities will be adjusted as specified herein to include extra embankment for subsurface consolidation.

Settlement plates will be measured and paid for in units of each, complete-in-place. This price shall include furnishing, installing, maintaining, and removing when no longer required.

Surcharge placement and removal will be measured in cubic yards as determined by the plan quantity and will be paid for at the contract unit price per cubic yard. This price shall include furnishing, placing, and removing surcharge material and disposing of surplus and unsuitable materials.

5. **If geotextile drainage fabric is a pay item**, measurement and payment will be in accordance with the requirements of Section 504.
6. **Geotextile for embankment stabilization** will be measured in square yards complete-in-place. Overlaps and seams will not be measured for separate payment. The accepted quantity of geotextile will be paid for at the contract unit price per square yard, which price shall be full compensation for furnishing, placing, lapping, or seaming material and for all materials, labor, tools, equipment, and incidentals necessary to complete the work.

Embankment with a stipulated CBR value shall be measured and paid for as embankment with the CBR value as specified.

Embankment without a stipulated CBR value shall be measured and paid for as embankment.

- (c) **Plan Quantities:** The quantity of regular excavation for which payment will be made when plan quantities are specified will be that specified in the Contract. However, borrow excavation; excavation for entrances; unsuitable material below the top of earthwork; undercut excavation; slide excavation; rock excavation that changes the slopes or causes undercut; and side, inlet, and outlet ditches not covered by plan cross sections will be measured in their original position by cross sections and computed in cubic yards by the average end area method.

Where there are authorized deviations from the lines, grades, or cross sections, measurements will be made and the volume computed in cubic yards by the average end area method for these deviations. The plan quantity will then be adjusted to include these quantities for payment.

When unauthorized deviations occur, allowances will not be made for overruns. However, if the deviation decreases the quantities specified in the Contract, only the actual yardage excavated will be allowed.

- (d) **Backfill:** Furnishing and placing backfill material, including backfill for undercut, will be included in the price for excavation and will not be measured for separate payment unless specific material is a pay item for backfill or unless suitable material is not available within the construction limits. When a specific material is a pay item, the unit of measure of the material will be in accordance with the unit specified in the Contract. When suitable backfill is not available within the construction limits, the material furnished and placed by the Contractor will be paid for in accordance with the requirements of Section 109.05.

- (e) **Erosion Control Items:**

1. **Limiting the scope of construction operations, shaping the top of earthwork, and constructing temporary earth berms and brush silt barriers for temporary erosion and siltation control** will not be measured for payment but shall be included in the price for other appropriate pay items.
2. **Erosion control riprap** will be measured and paid for in accordance with the requirements of Section 414.04.

3. **Temporary protective covering** will be measured and paid for in accordance with the requirements of Section 606.04.
4. **Check dams** will be paid for at the contract unit price per each. This price shall include furnishing, excavating, constructing, maintaining, and removing check dams when no longer required.

Synthetic check dams may be substituted for Type II Rock Check Dams (Standard EC-4) at no additional cost to the Department.

5. **Temporary silt fences** will be measured in linear feet, complete-in-place, excluding laps, and will be paid for at the contract unit price per linear foot. Decomposed or ineffective geotextile fabric replaced after 6 months from the installation date will be measured in linear feet of temporary silt fence and paid for at 1/2 the contract unit price for temporary silt fence. Decomposed geotextile fabric required to be replaced prior to 6 months after installation will not be measured for payment. This price shall include furnishing, installing, and maintaining the silt fence, including wire reinforcement and posts; removing and disposing of these materials, and dressing and stabilizing the area.
6. **Geotextile fabric** attached to brush barriers or existing fence or used for another function specified on the plans and not included in other pay items will be measured in square yards, complete-in-place, excluding laps, and will be paid for at the contract unit price per square yard. The brush barrier will not be measured for payment. The cost thereof shall be included in the price for clearing and grubbing. This price shall include trimming the brush barrier; furnishing, installing, maintaining, and removing the fabric; addressing and stabilizing the area.
7. **Temporary filter barriers** will be measured in linear feet, complete-in-place, excluding laps, and will be paid for at the contract unit price per linear foot. Decomposed or ineffective geotextile fabric replaced after 6 months from the installation date and decomposed or ineffective burlap fabric replaced after 3 months from the installation date will be measured in linear feet of temporary filter barrier and paid for at 1/2 the contract unit price for temporary filter barrier. Decomposed geotextile fabric required to be replaced prior to 6 months and decomposed burlap fabric required to be replaced prior to 3 months after installation will not be measured for payment. When permitted, baled straw silt barrier used in lieu of temporary filter barrier will be paid for in linear feet of temporary filter barrier, complete-in-place. This price shall include furnishing, installing, and maintaining the filter barrier, including filter barrier material and posts; removing and disposing of these materials; addressing and stabilizing the area. If the Contractor is permitted to use baled straw silt barrier in lieu of temporary filter barrier, payment will be made at the price for temporary filter barrier.
8. **Silt cleanout**, when approved or directed by the Engineer, will be measured as siltation control excavation in cubic yards of vehicular measurement in accordance with the requirements of Section 109.01 for the full volume of the vehicle.

Silt removal and sediment cleanout will be paid in cubic yard of siltation control excavation. Payment shall be full compensation for removal of silt and sediment approved or directed by the Engineer and for transportation and disposal of the material.

If approved or directed by the Engineer, the installation of additional temporary silt fence and temporary filter barrier in lieu of silt cleanout will be measured in linear feet as specified in (e)5. and (e)7. herein.

9. **Seeding materials** will be measured and paid for in accordance with the requirements of Section 603.
10. **Temporary erosion and siltation measures required to correct conditions created because of the Contractor’s negligence, carelessness, or failure to install permanent controls in accordance with the plans and sequence for performance of such work** will not be measured for payment.
11. **Slope drains** will be measured in units of each, per location regardless of size or length and will be paid for at the contract unit price per each. Raising of the slope drain and addition of pipe lengths will not be measured as a new location. This price shall include furnishing, installing, maintaining, and removing the drain and end section or portable flume.
12. **Sediment traps and basins** will be measured in cubic yards of sediment basin excavation and will be paid for at the contract unit price per cubic yard. This price shall include excavation, maintenance, and backfill or removing to original ground when no longer needed.
13. **Storm water management basin excavation** will be measured in cubic yards and will be paid for at the contract unit price per cubic yard. The price shall include excavation, maintenance, and shaping of basin.
14. **Temporary sediment basin excavation** will be measured in cubic yards and will be paid for at the contract unit price per cubic yard. The price shall include excavation, maintenance and when no longer required the removal of dam, pipe, riser pipe, trash rack, backfill and site restoration.
15. **Drop inlet silt trap** will be measured in units of each and paid for only one time during the life of the project.
16. **Dewatering basin** will be measured and paid for at the contract unit price per each. This price shall include furnishing, installing, maintaining, and when no longer required, removing the dewatering basin; backfill; and site restoration.
17. **Erosion control mulch** shall be paid for per square yard or acre. This includes all materials and equipment necessary for the application.

Payment will be made under:

Pay Item	Pay Unit
Regular excavation	Cubic yard
Borrow excavation	Cubic yard
Borrow excavation (CBR [value])	Cubic yard
Sediment basin excavation	Cubic yard
Siltation control excavation	Cubic yard

Pay Item	Pay Unit
Undercut excavation	Cubic yard
Minor structure excavation (Item)	Cubic yard
Earthwork	Lump sum
Embankment	Cubic yard
Embankment (CBR [value])	Cubic yard
Settlement plate	Each
Surcharge placement and removal	Cubic yard
Geotextile (Embankment stabilization)	Square yard
Check dam (Type) (Log, rock, or straw)	Each
Temporary silt fence	Linear foot
Geotextile fabric	Square yard
Temporary filter barrier	Linear foot
Slope drain	Each
Storm water management basin excavation	Cubic yard
Temporary sediment basin excavation	Cubic yard
Drop inlet silt trap (Type)	Each
Dewatering basin	Each
Erosion control mulch	Square yard or acre

SECTION 304—CONSTRUCTING DENSITY CONTROL STRIPS

304.01—Description This work shall consist of constructing control strips in accordance with the requirements of these specifications for the purpose of determining density requirements.

304.02—Materials

Materials shall conform to the requirements for the material to be used in the course. Material used in each control strip shall be furnished from the same source and shall be of the same type as the material used in the test sections whose density requirements are established by the control strip.

304.03—Equipment

Equipment shall be approved by the Engineer prior to use. The type and weight of compaction equipment shall be such that a uniform density is obtained throughout the depth of the layer of material being compacted. Control strips shall be compacted using equipment of the same type and weight to be used on the remainder of the course.

304.04—Procedures

The subgrade or pavement structure course upon which a control strip is constructed shall be approved by the Engineer prior to construction of the control strip.

One control strip shall be constructed at the beginning of work on each roadway and shoulder course and each lift of each course. An additional control strip shall be constructed when a change is made in

the type or source of material or whenever a significant change occurs in the composition of the material from the same source.

The project will be divided into “control strips” and “test sections” by the Engineer for the purpose of defining areas represented by each series of tests. The size of each control strip and test section will be in accordance with the requirements of VTM-10.

Control strips shall be constructed using the same procedure to be used in the construction of the remainder of the course. Rolling of the control strip shall be continued until no appreciable increase in density is obtained by additional roller coverages.

Upon completion of rolling, the mean density of the control strip will be based on 10 tests taken at randomly selected sites within the control strip area using a nuclear testing device. Compaction of the remainder of the course shall be governed by the density obtained in the control strip.

Each test section will be tested for required thickness. Areas that are deficient by more than the specified allowable tolerance shall be corrected in accordance with the applicable requirements of these specifications.

The Engineer may require an additional control strip after the completion of each 10 test sections.

Each control strip shall remain in place and become a section of the completed roadway.

304.05—Tolerances

If the mean density of a test section (roadway or shoulder) does not conform to the applicable requirements stated herein, the Contractor shall continue his compactive effort or shall rework the entire test section until the required mean density is obtained. If an individual test value does not conform to the requirements stated herein, the Contractor shall continue his compactive effort or shall rework the entire area represented by that test until the required density is obtained.

- (a) **Roadway:** The density of each test section will be evaluated based on the results of five tests performed at randomly selected sites within the test section. The mean density obtained for the five tests in each test section shall be at least 98 percent of the mean density obtained in the approved control strip. In addition, each individual test value obtained within a test section shall be at least 95 percent of the mean density obtained in the approved control strip.
- (b) **Shoulders:**
 1. **Aggregate shoulders:** The density of each test section of select or aggregate material used in the construction of shoulders will be evaluated based on the results of five tests performed at randomly selected sites within the test section. The mean density obtained for the five tests in each test section shall be within 95 ± 2 percent of the mean density obtained in the approved control strip. In addition, each individual test value obtained in a test section shall be within 95 ± 5 percent of the mean density obtained in the approved control strip.
 2. **Asphalt shoulders:** The density of each test section of asphalt concrete used in the construction of shoulders will be evaluated based on the results of five tests performed

at randomly selected sites within the test section. The mean density obtained for the five tests in each test section shall be at least 98 percent of the mean density obtained in the approved control strip. In addition, each individual test value obtained within a test section shall be at least 95 percent of the mean density obtained in the approved control strip.

304.06—Measurement and Payment

This item is considered incidental to the cost of furnishing, placing, and compacting the specified course and will not be measured for payment. The cost of constructing density control strips shall be included in the cost of the material for which the control strip is required.

SECTION 305—SUBGRADE AND SHOULDERS

305.01—Description

This work shall consist of constructing the subgrade and shoulders to the cross section and grade shown on the plans and within the specified tolerances indicated on the plans and in these specifications.

305.02—Materials

Materials may consist of material in place, treated material in place, or imported material. Imported material may be borrow material, select material, or other material as shown on the plans or specified in the Contract.

Materials other than regular excavation or borrow material that are shown on the plans or specified in the Contract shall conform to the applicable requirements of these specifications.

Geotextile materials used for subgrade stabilization shall conform to the requirements of Section 245.03(d).

305.03—Procedures

(a) Shaping and Compacting Subgrade:

- 1. Subgrade consisting of material in place:** The subgrade area shall be scarified to a depth of 6 inches for a distance of 2 feet beyond the proposed edges of the pavement on each side. If sandy or other soil is encountered that will not compact readily, clay or other suitable material shall be added or water applied in such quantity and within the allowable moisture content specified herein as will permit compaction of the subgrade. Subgrade material shall be compacted at optimum moisture, within ± 20 percent of optimum. The density of the subgrade when compared to the theoretical maximum density as determined in accordance with the requirements of VTM-1 shall conform to the following:

% Retained on No. 4 Sieve	Min. % Density
0–50	100
51–60	95
61–70	90

Percentages of material will be reported to the nearest whole number.

The subgrade shall then be shaped and checked to ensure a typical cross section and uniform grade prior to placement of any subsequent courses. If the subgrade becomes eroded or distorted prior to placement of material for subsequent courses, it shall be scarified, reshaped, and recompacted in accordance with the original requirements.

At the time of placing material for subsequent courses, the subgrade shall be compacted to the required density, free from mud and frost, and in a condition that will permit compaction of subsequent courses without distortion.

If the approved subgrade becomes unstable after placement of the subbase or base course and becomes mixed with the aggregate therein, material from the unstable area and contaminated aggregate shall be removed. The area shall then be backfilled and compacted, and the subsequent course thereon reconstructed.

2. **Subgrade consisting of treated materials in place:** Subgrade shall be treated in accordance with the requirements of the applicable provisions of Section 306.03 and Section 307.05 except that the tolerance for depth will be waived when lime or cement is being used to bridge or correct extremely weak areas.

If lime can be satisfactorily manipulated during initial mixing, and bridging of the weak area has been performed satisfactorily, additional mixing and compacting will not be required. Additional layers of fill may be placed without delay.

Field density determinations will be performed in accordance with the requirements of AASHTO T191, modified to include material sizes used in the laboratory determination of density; with a nuclear density testing device; or by other approved methods. When a nuclear device is used, the nuclear density determination for treated in-place subgrade material will be related to the density of the same material tested in accordance with the requirements of VTM-1 or VTM-12 and a control strip will not be required.

3. **Subgrade consisting of imported material:** The area to receive the material shall be graded to a true crown and cross section.

Material shall be placed and compacted in accordance with the requirements of the applicable specifications governing the type of material. When select material is used, material shall be placed and compacted in accordance with the requirements of Section 308.02 except that the provision for mixing will be waived. The top 6 inches of the finished subgrade shall be compacted in accordance with the requirements of the provisions of 1. herein.

The provisions of 1. herein that are not specifically amended herein shall apply. Imported material shall be placed in approximately equal layers not more than 8 inches

for commercial material and 6 inches for local material, compacted measure. Material will be tested after compaction for thickness and density. If material fails to conform to thickness requirements, it shall be corrected by scarifying, adding material if necessary, mixing, reshaping and recompacting, or removing and replacing. If the material fails to conform to density requirements, additional rolling will be required until the required density is obtained provided the material is compacted at optimum moisture, within ± 20 percent of optimum. If the moisture content is outside the allowable tolerance, the layer shall be scarified, brought to optimum moisture within the allowable tolerance, and recompacted to the specified density.

An aggregate spreader will not be required in the placement of select material and other imported materials used as subgrade and shoulder courses.

- (b) **Treatment of Unsuitable Subgrade:** When solid rock occurs in cuts or the material is not suitable for subgrade or finishing purposes, the roadbed shall be excavated below the grade shown on the plans in accordance with the standard drawings.

When solid rock or other unsuitable material has been removed, excavated areas shall be backfilled in accordance with the standard drawings.

- (c) **Finishing Subgrade:** The Contractor shall provide effective drainage for the subgrade and maintain it in a satisfactory condition until the next course is placed.

When practicable, the subgrade shall be prepared at least 500 feet ahead of placement of any subbase, base, or surface course. Material for subsequent courses shall not be placed until the subgrade has been checked and approved. The finished subgrade elevation shall be within ± 0.04 foot of the plan elevation unless otherwise specified. When imported material is used, acceptance of the course will be based on the requirements of Section 308.04.

- (d) **Geotextile (Subgrade Stabilization):** When geotextile for subgrade stabilization is required, it shall be placed as shown on the plans. Geotextile shall be spliced by an overlap of at least 2 feet or by sewing double-stitched seams with stitching spaced 1/4 inch to 1/2 inch apart or as shown on the plans.

- (e) **Shoulders:** Aggregate shoulder material shall be placed in accordance with the requirements of the applicable specifications governing the type of material or construction being used and shall be compacted at optimum moisture, within ± 2 percentage points of optimum. Except when aggregate material No. 18 is used, the density of the aggregate shoulder material, when compared to the theoretical maximum density as determined in accordance with the requirements of VTM-1 or VTM-12, shall conform to the following:

% Retained on No. 4 Sieve	Min. % Density
0–50	95–100
51–60	90–100
61–70	85–100

Percentages of material will be reported to the nearest whole number.

When aggregate material No. 18 is used, the density, when compared to the theoretical maximum density, shall be not less than 90 percent or more than 95 percent.

Aggregate in the guardrail section of fills, 1 foot from the roadway side of the guardrail face to the outside of the shoulder, shall be compacted until a density of at least 90 percent of the theoretical maximum density has been obtained. The asphalt mixture in this area shall be sealed immediately after the hot mixture is spread. Rolling of the asphalt mixture shall continue until roller marks are eliminated and a density of at least 85 percent of the theoretical maximum density has been obtained.

Stabilized and paved shoulders shall be constructed in accordance with the requirements of the applicable specifications for pavement stabilization. If the aggregate shoulder material becomes overconsolidated prior to final finishing, it shall be scarified for the approximate depth, reshaped, and recompact to conform to the specified grade and cross section.

Shoulders shall be constructed simultaneously with nonrigid types of base or surface courses other than asphalt concrete or in advance of the base or surface course so as to prevent spreading of base or surface materials. The area of shoulders 12 inches adjacent to the pavement shall be rolled simultaneously with the course being deposited.

Where base or surface courses are being constructed under traffic and are more than 1 inch in depth, shoulder material adjacent thereto shall be placed within 72 hours after placement of the base or surface course.

305.04—Measurement and Payment

When material in place is used for the subgrade and shoulders, no measurement will be made. Treated material in place will be measured in accordance with the method of measurement for the specified stabilizing material. When imported material is specified, it will be measured as follows:

- (a) **Select material, Type I**, will be measured in tons.
- (b) **Select material, Types II and III**, will be measured in cubic yards in its original position.
- (c) **Borrow** will be computed in its original position by cross-sectioning the area excavated. If cross-sectioning the area excavated is not practical, the quantity will be determined from compacted measurements in the road and then converted to pit volume.

When cubic yard measurement is specified and the plans do not show the thickness of material required, the material will be measured in the original position by the cross-section method. Where it is impractical to cross-section the area, measurement will be made in trucks in accordance with the requirements of Section 109.01.

When the ton unit is specified, the quantity shall be determined in accordance with the requirements of Section 109.01.

Moisture in excess of optimum, + 2 percentage points, will be deducted from the net weight of both truck and rail shipments.

Allowance will not be made for unauthorized depths beyond those shown on the plans and the allowable tolerances. When tonnage measurement is used, deduction for material exceeding the allowable tolerance will be based on 110 pounds per square yard per inch of depth.

When material in place is used for subgrade and shoulders, no separate payment will be made. The cost thereof shall be included in the price for other applicable pay items.

When imported materials are used, the subgrade and shoulders will be paid for at the contract unit price per cubic yard or per ton as specified. Treated material in place will be paid for in accordance with the requirements of the applicable specification.

Stabilized or paved shoulders shown as a pay item will be measured and paid for in accordance with the requirements of Section 306.04, Section 307.06, Section 312.05, or Section 315.08, as applicable.

Geotextile for subgrade stabilization will be measured in square yards complete-in-place. Overlaps and seams will not be measured for separate payment. The accepted quantity of geotextile will be paid for at the contract unit price per square yard, which price shall be full compensation for furnishing, placing, lapping, or seaming material and for all materials, labor, tools, equipment, and incidentals necessary to complete the work.

These prices shall include furnishing, hauling, placing, manipulating, and compacting material; clearing and grubbing local pits; material royalties; and access roads.

Payment will be made under:

Pay Item	Pay Unit
Borrow excavation	Cubic yard
Select material (Type and min. CBR)	Cubic yard or ton
Aggregate material (No.)	Cubic yard or ton
Aggregate base material (Type and no.)	Cubic yard or ton
Geotextile (Subgrade stabilization)	Square yard

SECTION 306—LIME STABILIZATION

306.01—Description

This work shall consist of stabilizing roadbed material and constructing one or more courses of the pavement structure using a mixture of soil or approved aggregates, lime or lime and fly ash, and water.

306.02—Materials

- (a) **Lime** shall conform to the requirements of Section 240.
- (b) **Fly ash** shall conform to the requirements of Section 241. Bulk fly ash may be transported dry in bulk trucks and stored in tanks or may be transported in the dampened condition, with a maximum of 15 percent moisture, and stockpiled at the job site. Excessively wet or contaminated surface material shall not be used in mixing operations.

- (c) **Water** shall conform to the requirements of Section 216.
- (d) **Aggregate** shall conform to the applicable requirements of Section 205, Section 207, and Section 208 or other requirements described in the Contract.

306.03—Procedures

Lime stabilization will not be permitted when aggregate or the surface on which the course is to be placed is frozen. Manipulation shall not be started until the surface is free from mud and frost and the temperature is at least 40 degrees F.

- (a) **Preparing the Roadbed:** The surface of the roadbed shall be cut or bladed to the approximate line, grade, and cross section. However, compaction of the roadbed for the depth of the material to be treated will not be required prior to application of lime. When the course placed directly on the roadbed is to be stabilized, the surface of the roadbed shall be prepared in accordance with the requirements of the applicable provisions of Section 305.

Temporary ramps constructed adjacent to existing pavements, bridges, culverts, and similar items shall be removed to the depth necessary to provide the required thickness of pavement structure.

Drains shall be cut through excavated shoulder material on shoulders to drain the roadbed. Drains shall be cut through windrowed base materials at sufficient intervals to prevent ponding of water. Windrowed material shall be moved, when necessary, to permit the sub-grade to dry.

- (b) **Preparing Materials:** The prepared roadbed shall be scarified to the depth and width required for stabilization. The material thus prepared shall be partially pulverized. The depth of scarification and the blading operation shall be controlled in such a manner that the surface of the roadbed below the scarified material shall remain undisturbed and shall conform to the established cross section. Prior to the beginning of stabilization work, material retained on the 3-inch sieve shall be removed.
- (c) **Applying Lime:** The application rate of lime shall be as shown on the plans or as directed by the Engineer. Lime may be applied to the partially pulverized material as a slurry or in a dry form. When quicklime is used in a dry form, it shall be applied at the same rate as hydrated lime.

Where quicklime is slaked on the project to produce a slurry, measurement will be calculated as indicated herein for each truckload using the certified lime purity for that load. No measurement will be made of any lime added or replaced for corrective measures during construction or for repairing damaged areas.

$A = \text{Certified weight of quicklime delivered} \times \text{percent purity} \times 1.32$

$B = \text{Certified weight of quicklime delivered} \times \text{percent inert material}$

$A + B = \text{Total hydrated lime produced (pay quantity)}$

Lime applied by slurry application shall be mixed with water in approved agitating equipment and applied to the roadbed as a thin water suspension or slurry. The distributing equipment shall provide continuous agitation from the mixing site until applied on the roadbed. The proportion of lime shall be such that the "Dry Solids Content" shall be at least 30 percent by weight. A lower percent solid may be authorized by the Engineer provided a uniform suspension of the slurry can be maintained. A weight and purity certification shall accompany each shipment of quicklime to be used in slurry applications.

Spreading equipment shall uniformly distribute the lime without excessive loss. No equipment except water trucks and equipment used for mixing and spreading shall pass over the spread lime until it is mixed. Any procedure that results in excessive loss or displacement of the lime shall be immediately discontinued.

When a stationary mixer is used to mix aggregate material, the lime may be added to the mix by an approved feeder.

- (d) **Adding Water:** Sufficient water shall be added by means of pressure water distributors or a traveling plant to provide a moisture content at the time of compaction of not less than the optimum for the mixture or more than optimum + 20 percent of optimum.
- (e) **Mixing:** Lime and water shall be mixed throughout the scarified material as thoroughly as practicable by using a disc harrow, by scarifying and blading, or by using other methods approved by the Engineer. The mixture shall then be spread over the roadbed. The surface shall be sealed with a steel wheel or pneumatic tire roller to retard the loss of moisture and then allowed to cure. Curing will be considered completed when a uniform material is produced in which at least 60 percent of the material, exclusive of aggregates, will pass the No. 4 sieve.

When a stationary mixer is used, the material may be placed, compacted, and finished immediately after mixing.

When traveling plants are used, additional mixing with blades, tillers, discs, harrows, or repeated passes of the plant may be required.

During the interval of time between application and mixing, lime that has been exposed to the open air for 6 hours or more or lime that has been lost because of washing or blowing will not be measured for payment.

- (f) **Compacting and Finishing:** The mixture shall be placed and compacted to a density of at least 95 percent of the maximum density determined in accordance with the requirements of VTM-1 or VTM-12. Light sprinkling may be required during placement operations to maintain the specified moisture content. Compaction shall be accompanied by sufficient blading to eliminate irregularities.

The surface shall be lightly scarified during finishing operations and bladed to eliminate imprints left by the equipment. Final rolling of the completed surface shall be accomplished with a pneumatic tire roller. Final compaction and finishing shall be completed within 12 hours after final mixing.

- (g) **Tolerances:** The finished stabilized course shall conform to the specified thickness, subject to the following tolerances: Thickness will be determined in accordance with the require-

ments of VTM-38A. Areas that are deficient in thickness by more than 1 inch shall be removed or reworked with an additional amount of lime equal to 50 percent of the original amount. In the case of stabilized base courses, the Contractor may correct sections deficient in depth by applying asphalt concrete provided such correction is authorized by the Engineer. Areas that are excessive in thickness by more than 2 inches shall be reworked, and an amount of lime equal to 50 percent of the original amount added to the mixture. Replacement and corrective work shall be at the Contractor's expense.

- (h) **Protecting and Curing:** After finishing of the subgrade, no vehicles except sprinkling equipment shall be permitted on the subgrade for a curing period of 7 days or until the next course is placed, whichever is less. During the curing period, the subgrade shall be lightly sprinkled with water at frequent intervals to prevent the surface from drying and cracking. The Contractor shall plan and prosecute the work in such a manner as to place the next course during the curing period. If the Contractor has not placed the next course by the end of the curing period, he shall apply liquid asphalt and cover material at the rate specified on the plans.

Damage to the stabilized course attributable to other phases of construction shall be repaired. At least one subsequent course shall be constructed on the stabilized course before hauling operations for the other phases of construction are permitted on the treated course. If the material loses the required stability, density, or finish before the next course is placed or the work accepted, it shall be recompacted and refinished at the Contractor's expense.

306.04—Measurement and Payment

Lime stabilization will be measured in tons of lime or fly ash, square yards of manipulation, and cubic yards or tons of aggregate material, complete-in-place, and will be paid for at the contract unit price per ton of lime or ton of fly ash, per square yard of manipulation, and per cubic yard or ton of aggregate material. Weighing shall be performed in accordance with the requirements of Section 109.01 except that transporting vehicles shall be tared prior to each load.

Manipulation shall include preparing the roadbed, scarifying, pulverizing, drying material, mixing, compacting, finishing, protecting, curing, and maintaining the completed course.

Payment will be made under:

Pay Item	Pay Unit
Lime	Ton
Fly ash	Ton
Manipulation (Depth)	Square yard
Aggregate material (Type)	Cubic yard or ton

SECTION 307—HYDRAULIC CEMENT STABILIZATION

307.01—Description

This work shall consist of stabilizing roadbed material as specified or as directed by the Engineer and constructing one or more courses of the pavement structure using a mixture of soil, or approved aggregates and hydraulic cement, on a prepared surface in accordance with the requirements of these specifications and in conformity with the lines, grades, typical sections, and cross sections shown on the plans or as established by the Engineer.

307.02—Materials

- (a) **Cement** shall conform to the requirements of Section 214, Type I, IP, or II. Cement shall be transported, stored, and otherwise protected in accordance with the requirements of Section 217.03.
- (b) **Water** shall conform to the requirements of Section 216.
- (c) **Asphalt** used for curing or priming shall conform to the applicable requirements of Section 210.
- (d) **Aggregate** shall conform to the applicable requirements of Section 205, Section 207, or Section 208 or other contract requirements.
- (e) **Select borrow** shall consist of approved material having the specified CBR.

307.03—Field Laboratory

When a field laboratory is furnished by the Department, the Contractor shall move the laboratory to various points along the project as necessary.

307.04—Weather Limitations

Cement stabilization will not be permitted when aggregate or the surface on which the course is to be placed is frozen. Manipulation operations shall not be started until the air temperature is at least 40 degrees F in the shade and rising. When material may be exposed to freezing temperatures during the first 24 hours of curing, the Contractor shall protect the stabilized material from freezing for 7 days or shall cover the stabilized surface with the next pavement course within 4 hours after the cement stabilization has been finished as specified.

307.05—Procedures

If full-width paving equipment is to be used in the subsequent placement of asphalt concrete base, the width of the stabilized course upon which the base will be placed may be extended 1 foot beyond the designed typical section on each side.

- (a) **Preparing Existing Surface:** When the roadbed is to be stabilized, its surface shall be cut or bladed to the approximate line, grade, and cross section. However, compaction of the roadbed for the depth of the material to be treated will not be required prior to application of cement. When the course placed directly on the roadbed is to be stabilized, the surface of the roadbed shall be prepared in accordance with the requirements of the applicable provisions of Section 305.03.

Additional material needed to bring the roadway surface into compliance with the required specifications shall be obtained from within the limits of the right of way, if available. When authorized, the Contractor shall obtain such material from borrow pits as provided for in Section 303.

The surface shall be sufficiently firm to support, without displacement, the construction equipment and shall be in such condition that the compaction can be obtained as specified herein. Soft, yielding, or wet areas shall be corrected and made stable before construction proceeds.

- (b) **Preparing Materials:** When the roadbed is to be stabilized, material to be treated shall be scarified and pulverized prior to application of cement. Pulverizing shall continue during mixing operations until at least 80 percent of the material, exclusive of coarse aggregate, will pass the No. 4 sieve. Any material retained on the 3-inch sieve and other objectionable objects shall be removed.

Applying and mixing cement with material in place or aggregate material shall be performed in accordance with the following methods except that aggregate subbase, aggregate base course, select material, and select borrow specified on the plans shall be mixed in accordance with the requirements of 2. herein. If the closest central mixing plant is located more than 30 road miles from the project, the Contractor may elect to mix cement with aggregate subbase, aggregate base, select material, and select borrow in accordance with the requirements of 1. herein provided an additional 1 percent cement by weight is added to the in-place mixing operation and the cement is mixed to a depth of approximately 1 inch less than the depth of the course being stabilized. No additional compensation will be allowed for the changes described herein.

1. **Mixed-in-place method:** Any additional material required shall be blended with the existing material prior to application of cement.

Cement shall be applied uniformly on the material to be processed. When bulk cement is used, the equipment shall be capable of handling and spreading the cement in the required amount. The moisture content of the material to be processed shall be sufficiently low to permit a uniform mixture of the aggregate material and cement. Spread cement that has been lost shall be replaced without additional compensation before mixing is started.

Mixing shall be accomplished by means of a self-propelled or self-powered machine equipped with a mechanical rotor or other approved type of mixer that will thoroughly blend the aggregate with the cement. Mixing equipment shall be constructed to ensure positive depth control. Care shall be taken to prevent cement from being mixed below the depth specified. Water shall be uniformly incorporated into the mixture. The water supply and distributing equipment shall be capable of supplying the amount of water necessary to obtain optimum moisture in the material within 1 hour. If more than one

pass of the mixer is required, at least one pass shall be made before water is added. Mixing shall continue after all water has been applied until a uniform mixture has been obtained for the full depth of the course.

Any mixture that has not been compacted and remains undisturbed for more than 30 minutes shall be remixed. If rain adds excessive moisture to the uncompacted material, the entire section shall be reworked. If the Contractor is unable to finish the section within the same day, the section shall be reconstructed and an amount equal to 50 percent of the original amount of cement shall be added to the mixture at the Contractor's expense.

2. **Central plant method:** Material shall be proportioned and mixed with cement and water in an approved central mixing plant. The plant shall be equipped with feeding and metering devices that will introduce materials into the mixer in the specified quantities. Mixing shall continue until a uniform mixture has been obtained.

Mixed material shall be transported to the roadway in suitable vehicles and spread on a moistened surface in a uniform layer by a self-propelled or other approved spreader. Not more than 60 minutes shall elapse between the start of mixing and the start of compacting the cement-treated mixture on the prepared subgrade.

- a. **Mixing aggregate subbase and base material:** The cement content will be determined by the titration method as described in VTM-40. Sampling and testing for determining cement content will be performed at the plant. However, nothing herein shall be construed as waiving the requirements of Section 106.06 and Section 200.02.

Acceptance for cement content will be based on the mean of the results of tests performed on samples taken in a stratified random manner from each lot. The rate of sampling will be four samples per lot. A *lot* of material is defined as 2,000 tons, or 4,000 tons for contract items in excess of 50,000 tons, of material unless the project requires less than 2,000 tons; the amount of material necessary to complete the project is less than 2,000 tons, or 4,000 tons when the contract item is in excess of 50,000 tons; a portion of the lot is rejected for deficient cement content; the job-mix formula for the aggregates is modified within a lot; or a portion of the lot is rejected for an excessive liquid limit or plasticity index.

A lot will be considered acceptable for cement content if the mean result of the test(s) is within the following process tolerance(s) of the plan design for the number of tests taken: mean of two tests, -1.1 percent; mean of three tests, -0.9 percent; mean of four tests, -0.8 percent. However, no one sample shall have a cement content more than 1.6 percent below the design cement content.

If an individual test result indicates that the cement content of the material represented by the test is deficient by more than 1.6 percent from the design cement content, the portion of the material represented by the sample will be considered a separate part of the lot and shall be removed from the road.

If the value of the test results falls below the allowable process tolerance, a payment adjustment will be applied to the contract unit price at the rate of 1.0 percent for each 0.1 percent the material is outside the process tolerance. If the total ad-

justment is 8.0 percent or less and the Contractor does not elect to remove and replace the material, the contract unit price paid for the material will be reduced at the rate specified herein. The adjustment will be applied to the tonnage represented by the samples.

- b. **Mixing select borrow:** Cement in the mixture shall not vary more than ± 7.0 percent by weight from that specified. Feeders and meters for introducing cement into the mixer shall be of such design that the amount of cement can be accurately determined before cement is introduced into the mixer.
- (c) **Compacting and Finishing:** Prior to the beginning of compaction, the mixture shall be brought to a uniformly loose condition for its full depth and shall have a moisture content of not less than optimum or more than optimum + 20 percent of optimum. For subgrade stabilization, the mixture shall be compacted to a density of at least 100 percent of the maximum density as determined in accordance with the requirements of VTM-1 or VTM-12. For sub-base and base stabilization, the mixture shall be compacted to conform to the density requirements of Section 309.05.

Compaction equipment shall be subject to the approval of the Engineer, and the number of such units shall be sufficient to ensure the specified density and completion of the processed section within 4 hours from the time the water is added to the mixture. Initial compaction of soil mixtures shall be accomplished with a tamping roller.

After the mixture has been compacted, the surface shall be shaped to the required lines, grades, and cross sections.

If the material to be shaped is a type in which surface compaction planes will form, the Contractor shall lightly scarify the surface continuously with a drag harrow or similar equipment during the shaping operation. The surface shall then be rolled with steel wheel or pneumatic tire rollers, or both. The moisture content of the surface material shall be maintained at not less than the specified optimum during finishing operations. Compacting and finishing operations shall be completed within the specified time and carried out in a manner that will produce a smooth, dense surface, free from surface compaction planes, cracks, ridges, or loose material.

- (d) **Construction Joints:** Each day's operation shall tie into the completed work of the previous day by the remixing of approximately 2 feet of the completed course prior to the processing of additional sections. An amount equal to 50 percent of the original amount of cement shall be added to such sections. When the completed section remains undisturbed for more than 24 hours, a transverse construction joint shall be made by cutting back into the completed work to form an approximate vertical face.
- (e) **Tolerances:** The finished stabilized course shall conform to the specified thickness and density, subject to the following tolerances:
 1. **Density:** The density of the completed work for each day's operations will be determined at representative locations. Any portion on which the density is more than 5 pounds per cubic foot less than that specified shall be removed and replaced.
 2. **Thickness:** Thickness will be determined in accordance with the requirements of VTM-38A. The Contractor shall remove and replace areas that are deficient in

thickness by more than 1 inch or, with the approval of the Engineer; the Contractor shall correct sections on stabilized base courses that are deficient in depth by applying asphalt concrete at his own expense. Mixed-in-place areas that are excessive in thickness by more than 1 inch shall be removed and replaced.

When the central plant method of mixing is used, acceptance of the course will be based on the requirements of Section 308.04 except when the depth is deficient by more than 1 inch. In such event, correction shall be as specified herein.

- (f) **Protecting and Curing:** The next course may be placed after the cement stabilization has been approved. In the event the next pavement course is not placed immediately, the cement-treated aggregate course shall be moist cured continually or covered by the application of liquid asphalt to prevent surface drying until the next pavement course is placed. The Contractor shall endeavor to place the next pavement course within 7 days after cement stabilization is finished. In the event this is not possible and a liquid asphalt cover has not been applied, the Contractor shall either seal the cement-stabilized layer with approved cover material or continually maintain the surface of the cement-stabilized course with moisture until the next pavement course can be successfully applied. The surface of the cement-treated aggregate course shall be maintained in such a manner that the entire surface of the course remains in a moistened condition. If asphalt cover material is used, it shall be applied at the rate of approximately 0.25 gallon per square yard or as shown on the plans. The Engineer shall direct the exact rate of application necessary to produce full coverage without excessive runoff. If asphalt is used, it shall be applied with an approved pressure distributor as specified in Section 314.04 and the asphalt material shall be immediately covered with the specified cover material.

Prior to placing the next course or applying asphalt cover material, the surface of the cement-stabilized layer shall be lightly moistened. In no case shall the cement-treated aggregate course be allowed to dry out completely or go uncovered through the winter. The stabilized course shall be tightly knit and free from loose and extraneous material.

The Contractor shall maintain the cement-stabilized course, including shoulders and ditches, within the limits of the Contract in a condition satisfactory to the Engineer from the time work first starts until the work is officially accepted. Maintenance shall include immediate repairs of defects that may occur either before or after cement is applied, which work shall be performed by the Contractor and repeated as often as is necessary to keep the course continuously intact. Repairs to the course shall be performed in a manner that will ensure the restoration of a uniform surface and stability of the area repaired.

307.06—Measurement and Payment

Hydraulic cement stabilization will be measured in tons of hydraulic cement, cubic yards or tons of aggregate, and square yards of manipulation in accordance with the requirements of Section 109.01 and will be paid for at the contract unit price per ton of hydraulic cement, per ton or cubic yard of aggregate, and per square yard of manipulation for the depth specified. This price shall include furnishing and applying water for moisture curing and, when grading is not a pay item, restoring shoulders and ditches.

Hydraulic cement-stabilized aggregate material or aggregate base material will be measured in cubic yards or tons and will be paid for at the contract unit price per ton or cubic yard. This price shall

include furnishing and installing cement, aggregate, and moisture for curing and, when grading is not a pay item, restoring shoulders and ditches.

Cement-stabilized select borrow will be measured in cubic yards, pit measure, in accordance with the requirements of Section 109.01 and will be paid for at the contract unit price per cubic yard. This price shall include furnishing component and curing materials and hauling, placing, and curing the cement-stabilized material.

When bulk cement is used, scales capable of weighing loaded cement transports or lesser loads shall be provided at locations approved by the Engineer. Weighing shall be performed in accordance with the requirements of Section 109.01 except that transporting vehicles shall be tared prior to each load.

Manipulation, when a pay item and the Contractor elects to centrally mix the materials, shall be paid for in accordance with the quantity of manipulation shown on the plans. Manipulation shall include only the mixing operation.

Asphalt and cover material for curing will not be measured for separate payment.

Payment will be made under:

Pay Item	Pay Unit
Hydraulic cement	Ton
Aggregate material (No.)	Cubic yard or ton
Aggregate base material (Type and no.)	Cubic yard or ton
Cement-stabilized select borrow (Min. CBR)	Cubic yard
Manipulation (Depth)	Square yard
Cement-stabilized aggregate material (No.)	Cubic yard or ton
Cement-stabilized aggregate base material (Type and no.)	Cubic yard or ton

SECTION 308—SUBBASE COURSE

308.01—Description

This work shall consist of furnishing and placing one or more courses of mineral aggregate on a prepared subgrade in accordance with the required tolerances within these specifications and in conformity with the lines, grades, typical sections, and cross sections shown on the plans or as established by the Engineer.

308.02—Materials

Material shall conform to the requirements of Section 208.02(a) except where other types of aggregate material are specified in the Contract, in which case the applicable specifications governing the material shall apply. When material is obtained from local sources, the sources shall conform to the requirements of Section 106.03.

308.03—Procedures

Prior to placement of the subbase course, the subgrade shall be constructed in accordance with the requirements of the applicable provisions of Section 304 and Section 305.

Subbase material shall be mixed in an approved central mixing plant of the pugmill or other mechanical type in accordance with the requirements of Section 208.05. The mixed material shall be placed on the subgrade by means of an approved aggregate spreader, except that the use of such spreader will not be required where the material is being applied solely for the temporary maintenance of traffic or where the width of the course shown on the plans is transitional and impracticable to place with a spreader box.

Where the required thickness is more than 6 inches, the material shall be spread and compacted in two or more layers of approximately equal thickness. The compacted thickness of any one layer shall be not more than 6 inches. When vibrating or other approved types of special compacting equipment are used, the compacted depth of a single layer of subbase course may be increased to 10 inches upon the approval of the Engineer.

Each layer of subbase course shall be compacted at optimum moisture, within ± 2 percentage points of optimum. The density of each layer of subbase aggregate material, when compared to the theoretical maximum density as determined in accordance with the requirements of VTM-1, shall conform to the following:

% Material Retained on No. 4 Sieve	Min. % Density
0–50	100
51–60	95
61–70	90

Percentages shall be reported to the nearest whole number.

Not more than one sample in every five shall have a density less than that specified, and the density of such a sample shall be not more than 2 percent below that specified.

If the surface of the subbase becomes uneven or distorted and sets up in that condition, it shall be scarified, reshaped, and recompact. If the subbase when compacted and shaped shows a deficiency in thickness or if depressions occur in the surface, the Contractor shall scarify such sections at his own expense before additional material is added.

Field density determinations will be performed with a nuclear field density device using the density control strip as specified in Section 304 and VTM-10 or in accordance with the requirements of AASHTO T191. The method of density determination will be as directed by the Engineer.

308.04—Tolerances

The thickness of the subbase course will be determined by the depth measurement of holes dug in the subbase in accordance with the requirements of VTM-38B.

Acceptance of the subbase course for the physical property of depth will be based on the mean result of tests performed on samples taken from each lot of material placed. A *lot* of material is defined as

308.04

the quantity being tested for acceptance except that the maximum lot size will be 2 miles of paver application width.

A lot will be considered acceptable for depth if the mean result of the tests is within the following tolerance of the plan depth for the number of tests taken except that each individual test shall be within ± 1.00 inch of the plan depth; mean of two tests, ± 0.75 inch; mean of three tests, ± 0.60 inch; and mean of four tests, ± 0.50 inch.

If an individual depth test exceeds the ± 1.00 inch tolerance, that portion of the lot represented by the test will be excluded from the lot. If the individual test result indicates that the depth of material represented by the test exceeds 1.00 inch, the Contractor will not be paid for that material in excess of the tolerance throughout the length and width represented by the test. If the individual test result indicates that the depth of the material represented by the test is deficient by more than 1.00 inch, correction of the subbase course represented by the test shall be made as specified herein.

If the mean depth of a lot of material is in excess of the allowable tolerance, the Contractor will not be paid for that material in excess of the tolerance throughout the length and width represented by the test.

If the mean depth of a lot of material is deficient by more than the allowable tolerance, correction will not normally be required and the Contractor will be paid for the quantity of material that has been placed in the lot.

For excessive depth subbase courses, when tonnage measurement is used, the rate of deduction from the tonnage allowed for payment as subbase material will be calculated at a weight of 110 pounds per square yard per inch of depth in excess of the tolerance. Areas that are deficient in depth by more than 1.00 inch and areas that do not provide a smooth uniform surface shall be scarified, material added or removed; reshaped; and recompacted to the specified density so as to conform with the depth tolerance and provide a smooth, uniform surface.

308.05—Measurement and Payment

Subbase course will be measured in cubic yards or tons as specified and will be paid for at the contract unit price per cubic yard or ton. When the cubic yard unit is specified, the quantity will be determined by compacted measurements on the road unless otherwise specified. When the ton unit is specified, the quantity shall be determined in accordance with the requirements of Section 109.01.

This price shall include furnishing, hauling, placing, manipulating, and compacting subbase course; clearing and grubbing local pits; material royalties; and access roads.

Moisture in excess of optimum + 2 percentage points will be deducted from the net weight of both truck and rail shipments.

Payment will be made under:

Pay Item	Pay Unit
Aggregate material (No.)	Cubic yard or ton
Aggregate base material (Type and no.)	Cubic yard or ton

SECTION 309—AGGREGATE BASE COURSE

309.01—Description

This work shall consist of furnishing and placing one or more courses of aggregates and additives, if required, on a prepared surface in accordance with the requirements of these specifications and in conformity with the lines, grades, and typical sections and cross sections shown on the plans or as established by the Engineer.

309.02—Materials

- (a) **Aggregate material** shall conform to the requirements of Section 208.02(b) except where other types of aggregate material are specified, in which case the applicable specifications governing the material shall apply.
- (b) **Calcium chloride and sodium chloride** shall conform to the requirements of Section 239.

309.03—Equipment

Equipment used for the construction of aggregate base course shall be approved prior to performance of such work. Any machine, combination of machines, or equipment that will handle the material without undue segregation and produce the completed base in accordance with the requirements of these specifications for spreading, moistening, mixing, and compacting will be acceptable.

309.04—Procedures

The surface or course upon which the base course is to be placed shall be prepared in accordance with the requirements of the applicable provisions of Section 304 and Section 305.

Base course material shall be mixed in an approved central mixing plant of the pugmill type. The mixed material shall be placed by means of an approved aggregate spreader.

309.05—Density Requirements

Where the required thickness is more than 6 inches, the material shall be spread and compacted in two or more layers of approximately equal thickness. The compacted thickness of any one layer shall not exceed 6 inches except when vibrating or other approved types of special compacting equipment are used. In such event, the compacted depth of a single layer of the base course may be increased to 10 inches upon the approval of the Engineer.

After mixing and shaping, each layer shall be compacted at optimum moisture within ± 2 percentage points of optimum. The density of each layer of base aggregate material, when compared to the theoretical maximum density as determined in accordance with the requirements of VTM-1, shall conform to the following:

% Material Retained on No. 4 Sieve	Min. % Density
0–50	100
51–60	95
61–70	90

Percentages shall be reported to the nearest whole number.

Not more than one sample in every five shall have a density less than that specified, and the density of such sample shall be not more than 2 percent below that specified. The surface of each layer shall be maintained during the compaction operations in a manner such that a uniform texture is produced and the aggregates are firmly keyed. Water shall be uniformly applied over the base materials during compaction in the amount necessary to obtain proper density.

Irregularities in the surface shall be corrected by scarifying, remixing, reshaping, and recompacting until a smooth surface is secured. The surface shall thereafter be protected against the loss of fine materials by the addition of moisture, when necessary, and shall be maintained in a satisfactory and smooth condition until accepted by the Engineer.

The base course will be tested in place for depth and density. Field density determinations will be performed with a nuclear field density device, using a density control strip as specified in Section 304 and VTM-10, or in accordance with the requirements of AASHTO T191. The method of density determination will be as directed by the Engineer.

Acceptance of the aggregate base course for depth will be based on the requirements of Section 308.

309.06—Measurement and Payment

Aggregate base course will be measured in cubic yards or tons, as specified, and will be paid for at the contract unit price per cubic yard or ton. When the cubic yard unit is specified, the quantity will be determined by compacted measurements on the road unless otherwise specified. When the ton unit is specified, the quantity shall be determined in accordance with the requirements of Section 109.01 and moisture, in excess of optimum + 2 percentage points, will be deducted from the net weight of both truck and rail shipments.

Calcium chloride and sodium chloride will be measured in tons and will be paid for at the contract unit price per ton.

These prices shall include preparing and shaping the subgrade or subbase and shoulders, adding moisture, removing and replacing unstable subgrade or subbase and constructing the base course thereon, and filling test holes.

Payment will be made under:

Pay Item	Pay Unit
Aggregate base material (Type/no.)	Cubic yard or ton
Aggregate material (No.)	Cubic yard or ton
Calcium chloride	Ton
Sodium chloride	Ton

SECTION 310—TACK COAT

310.01—Description

This work shall consist of preparing and treating an existing asphalt or concrete surface with asphalt in accordance with the requirements of these specifications and in conformity with the lines shown on the plans or as established by the Engineer.

310.02—Materials

Asphalt for tack coat shall be CRS-1, CRS-2, CRS-1h, or CSS-1h and shall conform to the requirements of Section 210. CMS-2, conforming to the requirements of Section 210, may be used during the winter months. With the exception of CMS-2, asphalt for tack coat may be diluted with 50 percent water provided that resulting material produces a uniform application of the tack.

310.03—Procedures

Equipment for heating and applying asphalt shall conform to the requirements of Section 314.04(b). The maximum application temperature of liquid asphalt shall conform to the requirements of Table III-1.

TABLE III-1
Liquid Asphalt Application Temperature

Grade	Max. Temperature (°F)
RC-70	180
RC-250	220
RC-800	225
RC-3000	290
MC-70	180
MC-250	220
MC-800	255
MC-3000	290
AC-5	300
AC-10	300
AC-20	300
AC-40	300
RS-2	175
SS-1h	180
AE-4	150
CRS-2	175
CSS-1h	180
CMS-2	200
CRS-1h	175
CRS-1	175

The existing surface shall be patched, cleaned, and rendered free from irregularities to the extent necessary to provide a reasonably smooth and uniform surface. Unstable corrugated areas shall be removed and replaced with suitable patching materials. The edges of existing pavements that are to be adjacent to new pavement shall be cleaned to permit adhesion of asphalt.

Tack material shall be uniformly applied with a pressure distributor conforming to the requirements of Section 314.04(b). Hand spray equipment shall not be used except in areas inaccessible by a pressure distributor. Undiluted asphalt shall be applied at the rate of 0.05 to 0.10 gallons per square yard. Diluted asphalt shall be applied at the rate of 0.10 to 0.15 gallons per square yard.

The tack coat shall be applied in a manner to offer the least inconvenience to traffic and permit one-way traffic without pick up or tracking of the asphalt.

The tack coat shall not be applied immediately prior to the course being placed. The tack coat shall be applied in accordance with the same weather limitations that apply to the course being placed. The quantity, rate of application, temperature, and areas to be treated shall be approved prior to application.

During the application of asphalt, care shall be taken to prevent spattering adjacent items. The distributor shall not be cleaned or discharged into ditches or borrow pits, onto shoulders, or along the right of way. When not in use, equipment shall be parked so that the spray bar or mechanism will not drip asphalt on the surface of the traveled way.

310.04—Measurement and Payment

Tack coat, when a pay item, will be measured in gallons and will be paid for at the contract unit price per gallon. When not a pay item, the cost thereof shall be included in the price for other appropriate pay items.

Patching will be paid for at the contract unit price for the various items used unless a reconditioning item is included in the Contract.

Payment will be made under:

Pay Item	Pay Unit
Tack coat	Gallon

SECTION 311—PRIME COAT

311.01—Description

This work shall consist of preparing and treating an existing surface with asphalt, and cover material if required, in accordance with the requirements of these specifications and in conformity with the lines shown on the plans or as established by the Engineer.

311.02—Materials

- (a) **Asphalt** may be changed one viscosity grade by the Engineer during construction at no change in the contract unit price. Asphalt shall conform to the applicable requirements of Section 210.
- (b) **Cover material** shall conform to the applicable requirements of Section 202 or Section 203. Lightweight aggregate shall conform to the requirements of Section 206. Cover material shall not be hauled directly from a washing plant for immediate use in the work.

311.03—Procedures

The rates of application of materials shall be determined in accordance with the method described in Education Series No. 12 of the Asphalt Institute entitled *Asphalt Surface Treatments Construction Techniques*.

The weather limitations of Section 314.03 shall apply to asphalt prime coat work. When asphalt is to be used as a cover for cement stabilization or as a primer for asphalt concrete, the weather limitations specified for these particular operations shall apply.

Equipment for heating and applying asphalt and cover material shall conform to the requirements of Section 314.04. The maximum application temperature of the liquid asphalt shall conform to the requirements of Table III-1 in Section 310.03.

The surface to be primed shall be shaped to the required grade and section; rendered free from ruts, corrugations, segregated material, or other irregularities; and uniformly compacted.

Delays in priming may necessitate reprocessing or reshaping to provide a smooth, compacted surface.

Asphalt shall be applied by means of a pressure distributor in a uniform continuous spread. When traffic is maintained, not more than 1/2 the width of the section shall be treated in one application. Care shall be taken that the application of asphalt at junctions of spreads is not in excess of the specified amount. Excess asphalt shall be removed from the surface by a squeegee. Skipped areas or deficiencies shall be corrected.

During the application of asphalt, care shall be taken to prevent spattering adjacent items. The distributor shall not be cleaned or discharged into ditches or borrow pits, onto shoulders, or along the right of way. When not in use, equipment shall be parked so that the spray bar or mechanism will not drip asphalt on the surface of the traveled way.

When traffic is maintained, one-way traffic shall be permitted on the untreated portion of the roadbed. When the asphalt has been absorbed by the treated surface and will not pick up, traffic shall be transferred to the treated portion and the remaining width of the section primed.

The quantity, rate of application, temperature, and areas to be treated shall be approved before application of the prime coat.

If after application of the prime coat the asphalt fails to penetrate within the time specified and the roadway must be used by traffic, cover material shall be spread at the Contractor's expense in an amount that will prevent pick up of the asphalt.

311.04

311.04—Measurement and Payment

Prime coat will be measured and paid for at the contract unit price per gallon for asphalt and per ton for cover material.

Payment will be made under:

Pay Item	Pay Unit
Prime coat	Gallon
Cover material (Type)	Ton

SECTION 312—SEAL COAT

312.01—Description

This work shall consist of applying asphalt followed by applying cover material in accordance with the requirements of these specifications and in conformity with the lines shown on the plans or as established by the Engineer.

312.02—Materials

- (a) **Asphalt** may be changed one viscosity grade by the Engineer during construction at no change in the contract unit price. Asphalt shall conform to the applicable requirements of Section 210.
- (b) **Cover material** shall conform to the applicable requirements of Section 203. Lightweight aggregate shall conform to the requirements of Section 206. Cover material shall not be hauled directly from a washing plant for immediate use in the work.

312.03—Equipment

The following equipment or its equivalent is required:

- (a) equipment for heating and applying asphalt conforming to the requirements of Section 314.04(b)
- (b) a rotary power broom
- (c) at least one pneumatic tire roller. Additional rollers that may be required may be tandem steel wheel or three-wheel rollers weighing at least 8 tons. The pneumatic tire roller shall be self-propelled, and the gross load adjustable to apply 200 to 350 pounds per inch of rolling width as directed. Tires shall be designed for a tire pressure of at least 90 pounds per square inch. Steel wheel rollers shall be operated at a maximum speed of 3 miles per hour, and pneumatic tire rollers at a maximum speed of 5 miles per hour.

- (d) a mechanical roller-type hopper or a self-propelled aggregate spreader of an approved design

312.04—Procedures

The rates of application of materials shall be determined in accordance with the method described in Education Series No. 12 of the Asphalt Institute entitled *Asphalt Surface Treatments Construction Techniques*.

The weather limitations specified in Section 314.03 shall apply to seal coat work.

Seal coating operations shall not be started until the surface is thoroughly compacted and cleaned of dust, mud, and foreign matter and the section to be sealed has been approved by the Engineer.

Asphalt shall be applied by means of a pressure distributor in a uniform continuous spread over the section to be treated and within the temperature range given in Table III-1. A strip of building paper at least 3 feet in width and having a length equal to that of the spray bar of the distributor plus 1 foot shall be used at the beginning of each spread. If the cutoff is not positive, the use of paper may be required at the end of each spread. The paper shall be removed and disposed of legally. The distributor shall be moving forward at the proper application speed at the time the spray bar is opened. Skipped areas and deficiencies shall be corrected. Junctions of spreads shall be carefully made to ensure a smooth riding surface.

The length of the spread of asphalt shall be regulated by the quantity of cover material in loaded trucks on the project.

The spread of asphalt shall be not more than 6 inches wider than the width covered by the cover material from the spreading device. Asphalt shall not be allowed to chill, set up, dry, or otherwise impair retention of the cover material.

During asphalt application, care shall be taken to prevent spattering adjacent items. The distributor shall not be cleaned or discharged into ditches or borrow pits, onto shoulders, or along the right of way. When not in use, equipment shall be parked so that the spray bar or mechanism will not drip asphalt material on the surface of the traveled way.

Immediately following asphalt application, cover material shall be applied in full-lane widths up to 12 feet. Laps shall be made only at lane dividers or at the crown of the roadway. Successive laps at lane dividers and the roadway crown shall be staggered from 3 to 6 inches. Spreading shall be accomplished in a manner so that the tires of the truck or aggregate spreader do not contact the uncovered and newly applied asphalt.

If directed, cover material shall be moistened with water to eliminate or reduce dust coating of aggregate. Moistening shall be done the day before the use of aggregate.

Immediately after cover material is spread, deficient areas shall be covered by additional material. Rolling shall begin immediately behind the spreader and shall consist of at least three complete coverages.

After application of cover material, the wearing surface shall be lightly broomed or otherwise maintained until cured as directed. Maintenance of the surface shall include distributing cover material

312.04

over the surface to absorb free asphalt and cover any area deficient in cover aggregate. Maintenance shall be conducted so as not to displace embedded material. Excess material shall be swept from the surface by means of rotary brooms as required or as directed by the Engineer.

312.05—Measurement and Payment

Seal coat will be paid for at the contract unit price per gallon for liquid asphalt and per ton for cover material.

Liquid asphalt will be measured in gallons.

Cover material will be measured in tons, complete-in-place, in accordance with the requirements of Section 109.01. These prices shall include furnishing and applying materials and maintaining the treatment.

Payment will be made under:

Pay Item	Pay Unit
Liquid asphalt	Gallon
Cover material (Type)	Ton

SECTION 313—ASPHALT-STABILIZED OPEN-GRADED MATERIAL

313.01—Description

This work shall consist of furnishing and placing a course of asphalt-stabilized open-graded material on a prepared subbase or subgrade in accordance with the required tolerances in these specifications and in conformity with the lines and grades shown on the plans or established by the Engineer.

313.02—Materials

Asphalt-stabilized open-graded material shall conform to the requirements of Section 211 except as noted herein:

- (a) **Coarse aggregate** shall be Grade A crushed stone conforming to the requirements of Section 203 and shall conform to the soundness requirements of surface course stone.
- (b) **Fine aggregate** shall conform to the requirements of the Section 202.
- (c) **Asphalt cement** shall be PG 70–22.
- (d) **Reclaimed asphalt pavement** shall not be used as component material.

313.03—Proportioning

Stabilized open-graded material shall be designed to have an in-place coefficient of permeability of at least 1,000 feet per day when tested in accordance with VTM-84.

The following design range shall be used for asphalt-stabilized open-graded material:

Sieve	% Passing	
	Min.	Max.
1 in	100	100
3/4 in	88	100
1/2 in	70	90
No. 8	0	15
No. 200	0.5	4.5
Asphalt Content $4.3 \pm 0.3\%$		

Hydrated lime shall be used in all mixtures at the rate of at least 0.5 percent by weight of the total dry aggregates. Chemical additives may be used in addition to or in lieu of lime with the approval of the Engineer. Such approval will be based on previous approvals of chemicals used with the same aggregates in asphalt concrete mixes of other types as detailed in Section 211.

The mix temperature shall be between 250 degrees F and 280 degrees F.

Design test data will not be required.

Draindown testing shall be performed in accordance with the requirements of VTM-100. Draindown shall not exceed 0.3 percent.

313.04—Acceptance

Acceptance of aggregate coating in asphalt-stabilized open-graded material shall be 100 percent surface coverage of the aggregate as verified by visual inspection by the Engineer.

313.05—Placing limitations

Stabilized open-graded material shall not be placed when weather or surface conditions are such that the material cannot be properly handled, finished, or compacted.

Asphalt-stabilized open-graded material shall be placed only when the atmospheric temperature is above 40 degrees F and the surface temperature upon which it is to be placed is no less than 35 degrees F.

The surface upon which mixtures are to be placed shall be free of standing water at the time such materials are placed.

Asphalt-stabilized open-graded course shall not be cooled with water.

Vibratory rollers shall not be used on the asphalt-stabilized open-graded course.

313.06—Procedures

Stabilized open-graded material shall not be placed until the surface upon which it is to be placed has been approved by the Engineer. Preparation shall include provision for surface drainage away from the material to prevent contamination from surface water in the event of rainfall.

The Contractor shall prevent contamination of the stabilized open-graded material. Material that has been contaminated shall be removed and replaced promptly by the Contractor at no additional expense to the Department. Likely indications of contamination include, but are not limited to, the surface being clogged by dirt or other foreign material or observable material damaged as in the cases of loss of material stability.

The finished surface of the stabilized open-graded material shall be uniform and shall not vary at any point more than 0.5 inch above or below the grade shown on the plans or established by the Engineer.

Stabilized open-graded material with a surface higher than 0.5 inch above the grade shown on the plans or established by the Engineer shall be removed and replaced with material within the proper tolerance. If permitted by the Engineer, the high spots may be removed to within specified tolerance by any method that does not produce contaminating fines or damage the base to remain in place, except that grinding will not be permitted.

Stabilized open-graded material with a surface lower than 0.5 inch below the grade shown on the plans or established by the Engineer shall be removed and replaced with stabilized open-graded material that complies with these specifications to the proper tolerance or, if permitted by the Engineer, low areas may be filled with the next pavement course in the same operation in which the pavement is placed at no additional cost to the Department.

The Contractor shall not use the open-graded course as a haul road or storage area. Construction traffic will not be permitted on the open-graded course except for equipment required to place the next layer. Haul vehicles that are overweight or that have not had a legal load determination will not be permitted on the open-graded drainage course for any purpose.

Asphalt-stabilized open-graded material shall be placed in one layer by approved equipment conforming to the requirements of Section 315.03. Compaction shall begin when the internal mat temperature is approximately 150 degrees F to 200 degrees F. A static, steel, two-wheel roller shall compact the material in one to three passes in an established pattern approved by the Engineer. An 8- to 10-ton roller is recommended for such use. The mat shall be compacted sufficiently to support the placement of the next layer but not to the point that it is not free draining or that the aggregate is crushed.

Placement of the next higher pavement layer shall be suspended if any damage to the stabilized open-graded material is visible. Construction of the next layer shall not proceed until directed by the Engineer.

313.07—Measurement and Payment

Asphalt-stabilized open-graded material will be measured in tons and paid for at the contract unit price per ton, complete-in-place. This price shall be full compensation for furnishing and placing asphalt material including aggregate, lime, or other anti-stripping admixture.

Payment will be made under:

Pay Item	Pay Unit
Asphalt-stabilized open-graded material	Ton

SECTION 314—PENETRATION SURFACE COURSES

314.01—Description

This work shall consist of constructing a wearing surface of crushed stone, slag, or crushed gravel penetrated with asphalt in accordance with the requirements of these specifications and in conformity with the lines shown on the plans or as established by the Engineer.

314.02—Materials

- (a) **Asphalt** may be changed one viscosity grade by the Engineer during construction at no change in the contract unit price. Asphalt shall conform to the applicable requirements of Section 211.
- (b) **Aggregate** shall be crushed stone, slag, or crushed gravel that conforms to the applicable requirements of Section 203. Aggregate shall not be hauled directly from a washing plant and used in the work.
- (c) **Fine aggregate** shall be Grading B sand conforming to the requirements of Section 202.

314.03—Weather Limitations

Penetration courses shall not be placed when surfaces are wet, when the air temperature is below 50 degrees F, or when the surface temperature is below 70 degrees F. The Contractor shall furnish a properly calibrated infrared instrument for the purpose of measuring the surface temperature and shall measure the surface temperature prior to placement.

314.04—Equipment

Equipment shall be approved prior to performance of the work. Equipment that will handle the materials and produce the completed course or courses in accordance with the requirements of these specifications is acceptable.

- (a) **Spreaders:** Spreaders for coarse aggregate shall be self-propelled spreading and leveling machines or spreader boxes equipped with shoes or runners of sufficient width and length to preclude damage or displacement of the subgrade or other courses.

The mechanical spreader for the fine aggregate shall conform to the requirements of Section 312.03.

- (b) **Distributor:** The distributor shall be so designed, equipped, maintained, and operated that asphalt at the specified temperature range may be applied uniformly on variable widths of surface up to 15 feet at readily determined and controlled rates from 0.05 to 2.0 gallons per square yard, with uniform pressure, and with an allowable variation from any specified rate not to exceed 0.02 gallon per square yard. Distributor equipment shall include a tachometer, pressure gages, accurate volume-measuring devices, or a calibrated tank and a thermometer for measuring temperatures of the contents of the tanks. Distributors shall be equipped with a power unit for the pump and full circulation spray bars adjustable laterally and vertically. The distributor shall be equipped with a positive shutoff control that will prevent lapping at the junction of two applications. When necessary, the distributor shall be equipped with a positive means of deflecting the spray to prevent coating of adjacent structures and appurtenances. A connection shall be provided and hand-spraying equipment shall be used to cover variable-width areas, patches, and other areas where spray bar application is impractical or would result in excessive asphalt material.
- (c) **Rollers:** The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density.

314.05—Procedures

Cover material shall be applied in full-lane widths up to 12 feet. Laps shall be made only at lane dividers or at the crown of the roadway. Successive laps at lane dividers and the crown of the roadway shall be staggered from 3 to 6 inches.

Conditioning of the road surface shall conform to the requirements of Section 312.04.

- (a) **Rates of Application:**

	Asphalt (gal/sq yd)	Aggregate (lb/sq yd)
Light Courses		
Coarse aggregate No. 56		60–139
Asphalt for penetration	0.75–1.20	
Choke aggregate		
No. 68, or		20–30
No. 78, or		22–28
No. 8, or		18–25
Grading B sand		10–15
Asphalt for seal	0.15–0.30	
Seal aggregate, No. 78, or		22–28
Seal aggregate, No. 8		18–25
Heavy Courses		
Asphalt for tack coat	0.10–0.20	
Coarse aggregate, No. 56		140–200
Asphalt for penetration	1.30–1.80	
Choke aggregate, No. 68		20–30
Asphalt for seal	0.20–0.35	
Seal aggregate, No. 78 or		22–28
Seal aggregate, No. 8		18–25

(b) **Sequence and Methods:**

1. If deemed necessary or specified, a tack coat shall be applied in accordance with the requirements of Section 310 immediately prior to the application of coarse aggregate.
2. The coarse aggregate shall be uniformly spread on the prepared base or surface at the specified rate of application. This application shall be mixed and shaped by the use of multiple-blade road planers or other approved equipment.

Immediately following mixing and shaping operations, the surface shall be rolled with a 10-ton, three-wheel or tandem steel wheel roller and, for a heavy penetration surface course, uniformly choked with No. 68 aggregate. The surface will be tested by the Engineer using a 10-foot straightedge. The variation of the surface from the testing edge of the straightedge between any two contacts with the surface shall be not more than 1/4 inch. Humps or depressions exceeding the specified tolerance shall be corrected. For a light penetration course, the coarse aggregate shall be uniformly choked with the fine aggregate.

3. The prepared course shall be penetrated with asphalt at the rate specified and immediately covered with the choke aggregate. Rolling operations shall immediately follow the application of covering aggregate and shall continue until the treatment is bonded. Subsequent rolling and applications of covering aggregate, if required, shall be performed on successive days following the application.
4. After the penetration course has cured, a seal coat shall be applied and rolled.

314.06

314.06—Measurement and Payment

Asphalt will be measured in gallons.

Aggregate and **cover material** will be measured in tons, complete-in-place, in accordance with the requirements of Section 109.01.

Penetration surface course will be paid for at the contract unit price per gallon for asphalt and per ton for aggregate and cover material.

These prices shall include furnishing and applying materials and maintaining the treatment.

Payment will be made under:

Pay Item	Pay Unit
Liquid asphalt	Gallon
Cover material (Type)	Ton
Aggregate (No.)	Ton

SECTION 315—ASPHALT CONCRETE PAVEMENT

315.01—Description

This work shall consist of constructing one or more courses of asphalt concrete on a prepared foundation in accordance with the requirements of these specifications and within the specified tolerances for the lines, grades, thicknesses, and cross sections shown on the plans or as established by the Engineer.

315.02—Materials

- (a) **Asphalt concrete** shall conform to the requirements of Section 211. If SUPERPAVE design densities begin to exceed 98 percent of the theoretical maximum density during construction, the Contractor shall alter the design.
- (b) **Asphalt for tack coat and prime coat** shall conform to the requirements of Section 310. Asphalt may be changed one viscosity grade by the Engineer at no change in the contract unit price.
- (c) **Curb backup material** shall be asphalt concrete conforming to any surface or intermediate mixture listed in Table II-13 and Table II-14.
- (d) **Liquid asphalt coating (emulsion) for rumble strip** shall conform to the requirements of Section 210.

315.03—Equipment

- (a) **Hauling Equipment:** Trucks used for hauling asphalt mixtures shall have tight, clean, smooth metal bodies equipped with a positive locking metal tailgate. Metal surfaces in contact with asphalt mixtures shall be given a thin coat of an aliphatic hydrocarbon invert emulsion release agent (nonpuddling), a lime solution, or other material on the Department's list of approved release agents. Except where a nonpuddling release agent is used, the beds of dump trucks shall be raised to remove excess agent prior to loading. Only a nonpuddling agent shall be used in truck beds that do not dump. Each truck shall be equipped with a tarpaulin or other cover that will protect the mixture from moisture and foreign matter and prevent the rapid loss of heat during transportation.
- (b) **Asphalt Pavers:** The asphalt paver shall be designed and recommended by the manufacturer for the type of asphalt to be placed and shall be operated in accordance with the manufacturer's recommendations. Written recommendations pertaining to handling and placing the mix shall be made readily available on the project site to the Engineer. In the absence of the manufacturer's recommendations, the recommendations of the National Asphalt Pavement Association shall be followed. The paver, including when screed extensions are used, shall be capable of producing a smooth uniform texture, dense joints, and a smooth riding surface.
- (c) **Rollers:** Rollers shall be steel wheel, static or vibratory, or pneumatic tire rollers and shall be capable of reversing without backlash. Rollers shall be operated at speeds slow enough to avoid displacement of the mixture. The number and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. The use of equipment that results in excessive crushing of aggregate or marring of the pavement surface will not be permitted.

If during construction the equipment being used mars the surface to the extent that imperfections cannot satisfactorily be corrected or produces permanent blemishes, the use of the equipment shall be discontinued and the equipment shall be replaced with satisfactory units.

- (d) **Rotary Saw:** A gasoline-powered rotary saw with a carbide blade shall be furnished for cutting test samples from the pavement. The Contractor shall furnish gasoline, oil, additional carbide blades, and maintenance for the rotary saw. The Contractor shall cool the pavement prior to sawing the sample. In lieu of a rotary saw, the Contractor may furnish the necessary equipment for coring and testing 4-inch core samples in accordance with the requirements of VTM-22.

315.04—Placement Limitations

Asphalt concrete mixtures shall not be placed when weather or surface conditions are such that the material cannot be properly handled, finished, or compacted. The surface upon which asphalt mixtures are to be placed shall be free of standing water, dirt, and mud and the base temperature shall conform to the following:

- (a) **When the base temperature is above 80 degrees F,** mixture laydown will be permitted at any temperature conforming to the limits specified in Section 211.

- (b) **When the base temperature is between 40 degrees F and 80 degrees F**, the Nomograph, Table III–2, shall be used to determine the minimum laydown temperature of the asphalt concrete mixes. At no time should the minimum base and laydown temperatures be less than the following:

Mix Designation	Minimum Base Temperature	Minimum Laydown Temperature
A	40°F	250°F
D	50°F	270°F
E	50°F	290°F
M	50°F	290°F
S	50°F	290°F

The maximum temperature of the mixture shall conform to the requirements of Section 211.08.

- (c) **When the laydown temperature is between 301 degrees F and 325 degrees F**, the number of compaction rollers will be the same number as required for 300 degrees F.

Intermediate and base courses that are placed at rates of application that exceed the application rates shown in Table III–2 shall conform to the requirements for the maximum application rate shown for 8-minute and 15-minute compaction rolling as per number of rollers used.

Should the Contractor be unable to complete the compaction rolling within the applicable 8-minute or 15-minute period, the placing of asphalt mixture shall either cease until sufficient rollers are used or other corrective action is taken to complete the compaction rolling within the specified period.

Compaction rolling shall be completed prior to the mat cooling down to 175 degrees F. Finish rolling may be performed at a lower mat temperature.

The final asphalt pavement finish course shall not be placed until construction pavement markings are no longer required.

315.05—Procedures

- (a) **Base Course:** The subgrade or subbase shall be prepared as specified in Section 305. The course upon which the pavement is to be placed, including the area that will support the paving equipment, shall be graded and compacted to the required profile.
- (b) **Conditioning Existing Surface:** When the surface of the existing pavement or base is irregular, it shall be brought to a uniform grade and cross section as directed by the Engineer. The surface on which the asphalt concrete is to be applied shall be prepared in accordance with the requirements of the applicable specifications and shall be graded and compacted to the required profile and cross section.

When specified, prior to placement of asphalt concrete, longitudinal and transverse joints and cracks in hydraulic cement concrete shall be sealed by the application of an approved joint sealing compound.

Contact surfaces of curbing, gutters, manholes, and other structures projecting into or abutting the pavement and cold joints of asphalt shall be painted with a thick, uniform coating of asphalt prior to placement of asphalt mixture.

1. **Priming existing surface:** A tack or prime coat of asphalt shall be applied between the existing surface and each asphalt course placed thereafter. The tack or prime coat shall conform to the applicable requirements of Section 310 and Section 311.

Asphalt classed as cutbacks or emulsions shall be applied ahead of the paving operations, and the time interval between applying and placing the paving mixture shall be sufficient to ensure a tacky residue providing maximum adhesion of the paving mixture to the base. The mixture shall not be placed on tack or prime coats that have been damaged by traffic or contaminated by foreign material. Traffic shall be excluded from such sections.

On rich sections or those that have been repaired by the extensive use of asphalt patching mixtures, the tack coat shall be eliminated when directed by the Engineer.

Priming: When asphalt concrete to be placed has a total thickness of 4 inches or more, priming with asphalt material will not be required on aggregate subbase or base material.

Tacking: Application of tack at joints, adjacent to curbs, gutters, or other appurtenances, shall be applied with a hand wand at the rate of 0.2 gallon per square yard. At joints, the tack applied by the hand wand shall be 2 feet in width with 4 to 6 inches protruding beyond the joint for the first pass. Tack for the adjacent pass shall completely cover the vertical face of the mat edge, so that slight puddling of asphalt occurs at the joint, and extend a minimum of 1 foot into the lane to be paved. Milled faces that are to remain in place shall be tacked in the same way for the adjacent pass. Use of tack at the vertical faces of longitudinal joints will not be required when paving in echelon.

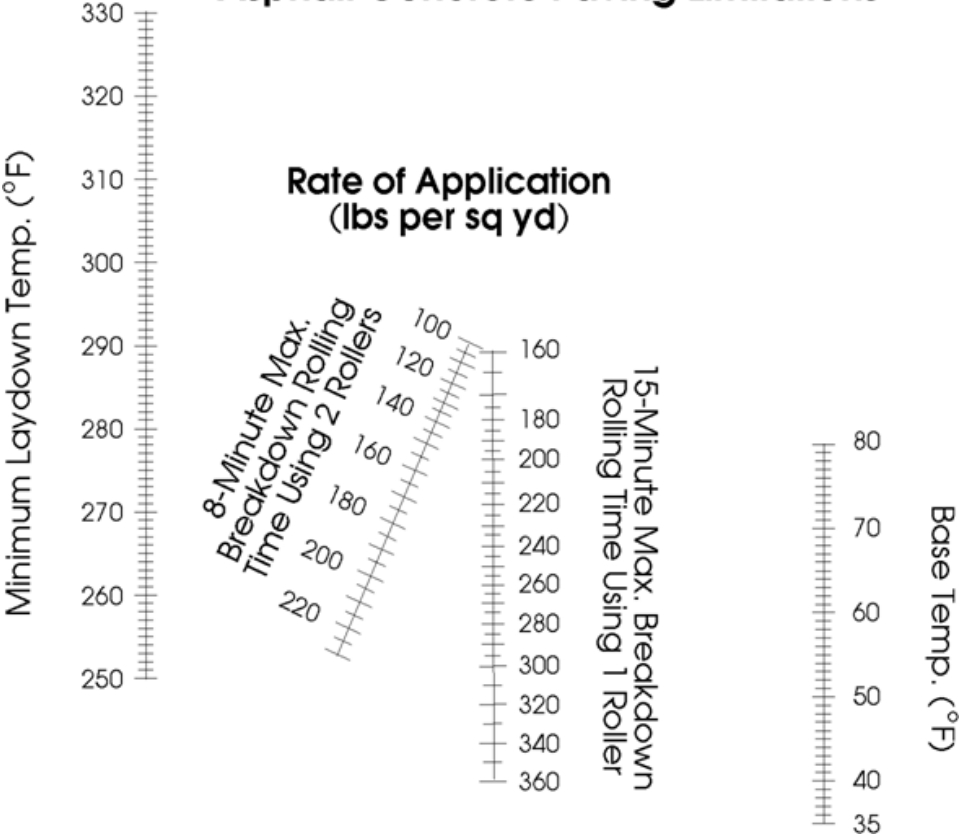
2. **Removing depressions and elevating curves:** Where irregularities in the existing surface would result in a course more than 3 inches in thickness after compaction, the surface shall be brought to a uniform profile by patching with asphalt concrete and thoroughly tamping or rolling until it conforms with the surrounding surface. The mixture used shall be the same as that specified for the course to be placed.

When the Contractor elects to conduct operations to eliminate depressions, elevate curves, and place the surface course simultaneously, he shall furnish such additional spreading and compacting equipment as required to maintain the proper interval between the operations.

- (c) **Placing and Finishing:** Asphalt concrete shall not be placed until the surface upon which it is to be placed has been approved by the Engineer.

TABLE III-2
Cold Weather Paving Limitations

Asphalt Concrete Paving Limitations



The edge of the pavement shall be marked by means of a continuous line placed and maintained a sufficient distance ahead of the paving operation to provide proper control of the pavement width and horizontal alignment.

An asphalt paver shall be used to distribute asphalt concrete over the widest pavement width practicable. Wherever practicable and when the capacity of sustained production and delivery is such that more than one paver can be operated, pavers shall be used in echelon to place the wearing course in adjacent lanes. Crossovers, as well as areas containing manholes or other obstacles that prohibit the practical use of mechanical spreading and finishing equipment, may be constructed using hand tools. However, care shall be taken to obtain the required thickness, jointing, compaction, and surface smoothness.

The longitudinal joint in one layer shall offset that in the layer immediately below by approximately 6 inches. However, the joint in the wearing surface shall be at the centerline of the pavement if the roadway comprises two traffic lanes or at lane lines if the roadway is more than two lanes in width. Offsetting layers will not be required when adjoining lanes are paved in echelon and the rolling of both lanes occurs within 15 minutes after laydown.

The Contractor shall have a certified Asphalt Field Technician present during paving operations where more than 100 tons of material is placed in a single location. Immediately after placement and screeding, the surface and edges of each layer shall be inspected and straightened by the technician and necessary corrections performed prior to compaction. The finished pavement shall be uniform and smooth.

The placement of asphalt concrete shall be as continuous as possible and shall be scheduled such that the interruption occurring at the completion of each day's work will not detrimentally affect the partially completed work. Material that cannot be spread and finished in daylight shall not be dispatched from the plant unless the use of artificial lighting has been approved. When paving is performed at night, sufficient light shall be provided to properly perform and thoroughly inspect every phase of the operation. Such phases include cleaning planed surfaces, applying tack, paving, compacting, and testing. Lighting shall be provided and positioned such as to not create a blinding hazard to the traveling public.

During compaction of asphalt concrete, the roller shall not pass over the end of freshly placed material except when a construction joint is to be formed. Edges shall be finished true and uniform.

Asphalt concrete SUPERPAVE pavement courses shall be placed in layers not exceeding 4.0 times the nominal maximum size aggregate in the asphalt mixture. The maximum thickness may be reduced if the mixture cannot be adequately placed in a single lift and compacted to the required uniform density and smoothness. The minimum thickness for a pavement course shall be no less than 2.5 times the nominal maximum size aggregate in the asphalt mixture. Nominal maximum size aggregate for each mix shall be defined as one sieve size larger than the first sieve to retain more than 10 percent aggregate as shown in the design range specified in Section 211.03, Table II-13. Base courses to be placed in irregularly shaped areas of pavement, such as transitions, turn lanes, crossovers, and entrances, may be placed in a single lift.

Overlays in excess of 165 pounds per square yard or with a milled depth greater than 1 1/2 inches shall be squared up prior to opening to traffic.

The milled roadway areas that are to be opened to traffic, excluding curb and gutter sections, shall have drainage outlets cut through the shoulder at locations designated by the Engineer. The Contractor shall plan and prosecute the milling operation to avoid the trapping of water on the roadway. Drainage outlets shall be restored to original grade, unless otherwise directed by the Engineer. The cost for cutting and restoring the drainage slots in the roadway shoulder shall be included in the price bid for other items of work.

The Contractor shall plan and prosecute a schedule of operations so that milled roadways will be overlaid with asphalt concrete as soon as possible. In no instance, shall the time lapse exceed 10 days after the milling operations, unless otherwise specified. The milled areas of the roadway shall be kept free of irregularities and obstructions that may create a hazard or annoyance to traffic in accordance with the requirements of Section 104.

A short ski or shoe shall be used to match the grade of the newly overlaid adjacent travel lane on primary, interstate, and designated secondary routes. Unless otherwise directed by the Engineer, a 24-foot minimum automatic grade control ski shall be used on asphalt mixtures on divided highways, with the exception of overlays that are less than full width and

the first course of asphalt base mixtures over aggregate subbases. Care shall be exercised when working along curb and gutter sections to ensure a uniform grade and joint.

The Contractor shall construct the final riding surface to tie into the existing surface by an approved method, which shall include the cutting of a notch into the pavement. In addition to notching, the Contractor may use an asphalt design containing a fine-graded mix to achieve a smooth transition from the new asphalt concrete overlay to the existing pavement, with the approval of the Engineer. The material shall be of a type to ensure that raveling will not occur. The cost for constructing tie-ins in the asphalt concrete overlay shall be included in the price bid for asphalt concrete.

- (d) **Compacting:** Immediately after the asphalt mixture is placed and struck off and surface irregularities are corrected, the mixture shall be thoroughly and uniformly compacted by rolling.

The surface shall be rolled when the mixture is in the proper condition. Rolling shall not cause undue displacement, cracking, or shoving.

The number, weight, and type of rollers furnished shall be sufficient to obtain the required compaction while the mixture is in a workable condition. The sequence of rolling operations and the selection of roller types shall provide the specified pavement density.

Immediately after the hot mixture is placed, it shall be sealed with rollers. Thereafter, rolling shall be a continuous process, insofar as practicable, and all parts of the pavement shall receive uniform compaction.

Rolling shall begin at the sides and proceed longitudinally parallel with the center of the pavement, each trip overlapping at least 1/2 the roller width, gradually progressing to the crown of the pavement. When abutting a previously placed lane, the longitudinal joint shall be rolled first, followed by the regular rolling procedure. On superelevated curves, rolling shall begin at the low side and progress to the high side by overlapping of longitudinal trips parallel with the centerline.

Displacements occurring as a result of reversing the direction of a roller or other causes shall be corrected at once by the use of rakes or lutes and addition of fresh mixture when required. Care shall be taken in rolling not to displace the line and grade of the edges of the asphalt mixture.

To prevent adhesion of the mixture to the rollers, the wheels shall be kept properly moistened with water or water mixed with a very small quantity of detergent or other approved material. Excess liquid will not be permitted.

Along forms, curbs, headers, walls, and other places not accessible to rollers, the mixture shall be thoroughly compacted with hot hand tampers, smoothing irons, or mechanical tampers. On depressed areas, a trench roller may be used or cleated compression strips may be used under the roller to transmit compression to the depressed area.

Edges of asphalt pavement surfaces shall be true curves or tangents. Irregularities shall be corrected.

The surface of the compacted course shall be protected until the material has cooled sufficiently to support normal traffic without marring.

(e) **Density:** Density shall be determined in accordance with the following:

1. The Contractor shall perform roller pattern and control strip density testing on surface, intermediate, and base courses in accordance with the requirements of VTM-76. The Contractor shall have a certified Asphalt Field Technician perform all density testing.

Density shall be determined by the backscatter method of testing using a thin-lift nuclear gage with printer, conforming to the requirements of VTM-81. Density test locations for the control strip and test sections shall be marked and labeled in accordance with the requirements of VTM-76. The Contractor shall furnish and operate the nuclear gage, which shall have been calibrated within the previous 12 months by an approved calibration service. In addition, the Contractor shall maintain documentation of such calibration service for a 12-month period. The required density of the compacted course shall be not less than 98.0 percent and not more than 102.0 percent of the target control strip density.

Nuclear density roller pattern and control strip density testing shall be performed on asphalt concrete overlays placed directly on surface treatment roadways and when overlays are placed at an application rate less than 125 pounds per square yard, based on 110 pounds per square yard per inch, on any surface. In these situations, sawed plugs or core samples will not be required and the minimum control strip densities as specified in Table III-3 will be waived. The required density of the compacted course shall be not less than 98.0 percent and not more than 102.0 percent of the target control strip.

**TABLE III-3
Density Requirements**

Mixture Type	Min. Control Strip Density (%)¹
SM-9.5A, 12.5A	92.5
SM-9.5D, 12.5D	92.2
SM-9.5E, 12.5E	92.2
IM-19.0A	92.2
IM-19.0D	92.0
BM-25.0A, BM-25.0D	91.5

¹The control strip density requirement is the percentage of theoretical maximum density of the job-mix formula by SUPERPAVE mix design or as established by the Engineer based on two or more production maximum theoretical density tests.

The project will be divided into “control strips” and “test sections” by the Engineer for the purpose of defining areas represented by each series of tests.

- a. **Control Strip:** Control strips shall be constructed in accordance with the requirements of these specifications and VTM-76.

The term *control strip density* is defined as the average of 10 nuclear determinations selected at stratified random locations within the control strip.

One control strip shall be constructed at the beginning of work on each roadway and shoulder course and on each lift of each course. An additional control strip shall be constructed when a change is made in the type or source of materials or compaction equipment; whenever a significant change occurs in the composition of the material being placed from the same source; or when there is a failing control strip. During the evaluation of the initial control strip, paving operations may continue. However, paving and production shall be discontinued during construction and evaluation of additional control strips. In the event that two consecutive control strips fail, subsequent paving operations shall cease until corrective action(s) has been taken with the approval of the Engineer. If it is determined with the Engineer's approval that the density cannot be obtained because of the condition of the existing pavement structure, the target control strip density shall be determined from the roller pattern that achieves the optimum density and shall be used on the remainder of the roadway that exhibits similar pavement conditions.

Either the Engineer or Contractor may initiate an additional control strip at any time.

The length of the control strip shall be approximately 300 feet, regardless of the width of the course being placed. On the first day of construction or beginning of a new course, the control strip shall be started between 500 and 1,000 feet from the beginning of the paving operation. The control strip shall be constructed using the same paving, rolling equipment, procedures, and thickness as shall be used on the remainder of the course being placed.

One nuclear reading shall be taken at each of 10 stratified random locations. No determination shall be made within 12 inches of the edge of any application width for surface and intermediate mixes or within 18 inches of the edge of any application width for base mixes. The average of these 10 determinations shall be the control strip density recorded to the nearest 0.1 pound per cubic foot. The minimum control strip density shall be determined in accordance with the requirements of VTM-76.

The control strip shall be considered a lot. If the control strip density conforms to the requirements specified in Table III-3, the control strip will be acceptable and the control strip density shall become the target control strip density. If the density does not conform to the requirements specified in Table III-3, the tonnage placed in the control strip and any subsequent paving prior to construction of another control strip will be paid for in accordance with Table III-4 on the basis of the percentage of the Table III-3 value achieved. The Contractor shall take corrective action(s) to comply with the density requirement specified in Table III-3.

TABLE III-4
Payment Schedule for Lot Densities

% of Target Control Strip Density	% of Payment
Greater than 102.0	95
98.0 to 102.0	100
97.0 to less than 98.0	95
96.0 to less than 97.0	90
Less than 96.0	75

- b. **Test section (lot):** For the purposes of acceptance, each day's production shall be divided into lots (test sections). The standard size of a lot shall be 5,000 linear feet of any pass made by the paving train regardless of the width of the pass or the thickness of the course. Pavers traveling in echelon will be considered as two passes. Each lot shall be divided into five sublots of equal length. When a partial lot occurs at the end of a day's production or upon completion of the project, the lot size shall be redefined as follows: If the partial lot contains one or two sublots, the sublots will be added to the previous lot. If the partial lot contains three or four sublots, the partial lot will be redefined to be an entire lot. Each lot shall be tested for density by taking a nuclear density reading from two random locations selected by the Engineer within each subplot. Readings shall not be taken within 12 inches of the edge of any application width for surface and intermediate mixes or within 18 inches of the edge of any application width for base mixes. The average of the subplot nuclear density readings will be compared to the target nuclear control strip density to determine the acceptability of the lot. Once the average nuclear density of the lot has been determined, the Contractor will not be permitted to provide additional compaction to raise the average. If two consecutive sublots produce nuclear density results less than 98 percent or more than 102 percent of the target nuclear control strip density, the Contractor shall immediately notify the Engineer and institute corrective action. By the end of the day's operations, the Contractor shall furnish the test data developed during the day's paving to the Engineer.

The tonnage of each lot will be based on the lot's width and length and the mixture application rate as designated in the Contract or as revised by the Engineer. Payment will be made in accordance with the requirements of Table III-4.

The Engineer at any time on any project may perform lot density verification testing. Lot density verification can be performed by using either a nuclear gage or plugs. The Contractor shall be responsible for taking plugs for testing. Testing of the plugs will be done by or in the presence of the Engineer.

Surface, Intermediate, and Base mixes:

When a nuclear gage is used, the Engineer will take 10 stratified random readings per lot. If, based on the average of the 10 readings, the density does not meet the requirement for 100 percent pay or the same pay percentage determined by the Contractor's testing for that lot, the Engineer will take readings at the 10 Contractor sites and then average the readings of the 20 sites. If the density still does not

conform to the requirements for 100 percent pay, payment for that lot will be in accordance with Table III-4 on the basis of the Engineer’s average of the 20 test results. If the Contractor questions the payment for the lot, the Contractor can request the referee procedure.

The referee procedure shall consist of the Department taking five plugs from the five sites closest to the average of the Engineer’s readings of the Contractor and Department sites. The density of the plugs will be determined. If the average density of the plugs does not conform to the requirements for 100 percent pay for the lot in question, payment for that lot will be in accordance with the specifications in Table III-4 on the basis of the percentage of the Table III-3 value achieved.

When plugs are used for lot density verification, five plugs shall be taken per lot. If the density of the plugs does not conform to the requirements for the lot in question, payment for that lot will be in accordance with the specifications in Table III-4 on the basis of the percentage of the Table III-3 value achieved.

2. **Surface, intermediate, and base courses** not having a sufficient quantity of material to run a nuclear density roller pattern and control strip shall be compacted to a minimum density of 91.5 percent of the theoretical maximum density as determined in accordance with the requirements of VTM-22. The Contractor shall be responsible for cutting cores or sawing plugs for testing by the Department. If the density is less than 91.5 percent, payment will be made in accordance with the requirements of Table III-5.

TABLE III-5

Payment Schedule for Surface, Intermediate and Base Courses (Not sufficient quantity to perform nuclear density roller pattern and control)

% TMD	% of Payment
Greater than 91.5	100
90.2-91.4	95
88.3-90.1	90
Less than 88.2	75

Any section in which a mixture (e.g., SM-9.0) is being placed at an application rate of less than 125 pounds per square yard, based on 110 pounds per square yard per inch, that does not have a sufficient quantity of material for a nuclear density roller pattern and control strip shall be compacted by rolling a minimum of three passes with a minimum 8-ton roller. No density testing will be required.

- (f) **Joints:** Transverse joints shall be formed by cutting back on the previous run to expose the full depth of the course. A coat of asphalt shall be applied to contact surfaces of transverse joints just before additional mixture is placed against the previously rolled material.

Joints adjacent to curbs, gutters, or adjoining pavement shall be formed by hand placing sufficient mixture to fill any space left uncovered by the paver. The joint shall then be set up with rakes or lutes to a height sufficient to receive full compression under the rollers.

- (g) **Rumble Strips:** This work shall consist of constructing rumble strips on mainline shoulders of highways by cutting 1/2-inch-deep concave depressions into existing asphalt concrete surfaces as shown on the detail drawings and as directed by the Engineer.

Rumble strips shall be installed in accordance with detail drawings for rumble strips (asphalt shoulder). The depressions shall have a concave circular shape with a minimum 1/2-inch depth at center and maximum 5/8-inch allowable depth at center. Depressions shall have a smooth finish with a maximum 1/16-inch variance between peaks and valleys of the depression.

Prior to beginning production work on mainline shoulders, the Contractor shall demonstrate to the Engineer the ability to achieve the desired surface regarding alignment, consistency, and conformity with these specifications and the plans. The test site shall be approximately 25 feet longitudinally at a site mutually agreed upon by the Contractor and Engineer.

Following cutting and cleaning depressions of waste material, the entire rumble strip area shall be coated with liquid asphalt coating (emulsion) using a pressure distributor at an approximate rate of 0.1 gallon per square yard. Overspray shall not extend more than 2 inches beyond the width of the cut and/or shall not come in contact with pavement markings.

Rumble strips shall not be installed on shoulders of bridge decks, in acceleration/deceleration lanes, on surface drainage structures, or in other areas identified by the Engineer.

Waste material resulting from the operation shall be removed from the paved surface and shall not be disposed of where waterways may be at risk of contamination.

- (h) **Saw-Cut Asphalt Pavement:** This work shall consist of saw-cutting the existing asphalt pavement to a depth shown on the plans and as directed by the Engineer.

315.06—Pavement Samples

The Contractor shall cut samples from the compacted pavement for testing for depth and density. Samples shall be taken for the full depth of the course at the locations selected by the Engineer. The removed pavement shall be replaced with new mixture and refinished. No additional compensation will be allowed for furnishing test samples and reconstructing areas from which they were taken.

315.07—Pavement Tolerances

- (a) **Surface Tolerance:** The surface will be tested by using a 10-foot straightedge. The variation of the surface from the testing edge of the straightedge between any two contacts with the surface shall be not more than 1/4 inch. Humps and depressions exceeding the specified tolerance shall be corrected or the defective work shall be removed and replaced with new material.
- (b) **Finished Grade Tolerance:** After placement of the final pavement layer, finished grade elevations shall be within ± 0.04 foot of the elevations indicated in the plans, unless otherwise specified, provided that the actual cross slope does not vary more than 0.20 percent

from the design cross slope indicated in the plans and the pavement thickness conforms to the thickness tolerances specified herein.

If determined by the Engineer that either the finished grade elevations or cross slope exceed the tolerances specified, the Contractor shall submit to the Engineer for approval a plan of corrective action.

- (c) **Thickness Tolerance:** The thickness of the base course will be determined by the measurement of cores as described in VTM-32B.

Acceptance of asphalt concrete base course for depth will be based on the mean result of measurements of samples taken from each lot of material placed. A *lot* of material is defined as the quantity being tested for acceptance except that the maximum lot size will be 1 mile of 24-foot-width base course.

A lot will be considered acceptable for depth if the mean result of the tests is within the following tolerance of the plan depth for the number of tests taken except that each individual test shall be within ± 0.60 inch of the plan depth: mean of two tests, ± 0.45 inch; mean of three tests, ± 0.35 inch; mean of four tests, ± 0.30 inch.

If an individual depth test exceeds the ± 0.60 -inch tolerance, that portion of the lot represented by the test will be excluded from the lot. If an individual test result indicates that the depth of material represented by the test is more than 0.60 inch, the Contractor will not be paid for that material in excess of the tolerance throughout the length and width represented by the test. If an individual test result indicates that the depth of the material represented by the test is deficient by more than 0.60 inch, correction of the base course represented by the test shall be made as specified hereinafter.

If the mean depth of a lot of material is excessive, the Contractor will not be paid for that material in excess of the tolerance throughout the length and width represented by the tests.

If the mean depth of a lot of material is deficient by more than the allowable tolerance, correction will not normally be required and the Contractor will be paid for the quantity of material that has been placed in the lot.

For excessive depth base courses, the rate of deduction from the tonnage allowed for payment as base course will be calculated at a weight of 115 pounds per square yard per inch of depth in excess of the tolerance. For sections of base course that are deficient in depth by more than 0.60 inch and less than 1.50 inch, the Contractor shall furnish and place material specified for the subsequent course to bring the base course depth within the tolerance. This material will be measured on the basis of tonnage actually placed, determined from weigh tickets, and paid for at the contract unit price for the base course material. Such material shall be placed in a separate course. If the deficiency is more than 1.50 inches, the Contractor shall furnish and place base course material to bring the base course thickness within the tolerance. Corrections for deficient base course depth shall be made in a manner to provide a finished pavement that is smooth and uniform.

When the Contract provides for the construction or reconstruction of the entire pavement structure, the surface and intermediate courses shall be placed at the rate of application shown on the plans within an allowable tolerance of ± 5 percent of the specified application rate for application rates of 100 pounds per square yard or greater and within 5 pounds per

square yard for application rates of less than 100 pounds per square yard. The amount of material exceeding the allowable tolerance will be deducted from the pay quantities.

When the Contract provides for the placement of surface or intermediate courses over existing pavement, over pavements constructed between combination curb and gutter, or in the construction or reconstruction of shoulders, such courses shall be placed at the approximate rate of application shown on the plans. However, the specified rate of application shall be altered where necessary to produce the required riding quality.

315.08—Measurement and Payment

Asphalt concrete base will be measured in tons and paid for at the contract unit price per ton. This price shall include preparing and shaping the subgrade or subbase, constructing and finishing shoulders and ditches, and removing and replacing unstable subgrade or subbase.

Asphalt concrete will be measured in tons and paid for at the contract unit price per ton. Net weight information shall be furnished with each load of material delivered in accordance with the requirements of Section 211. Batch weights will not be permitted as a method of measurement unless the Contractor's plant is equipped in accordance with the requirements of Section 211, in which case the cumulative weight of the batches will be used for payment.

Asphalt used in the mixtures, when a pay item, will be measured in tons in accordance with the requirements of Section 109.01 except that transporting vehicles shall be tared prior to each load. The weight shall be adjusted in accordance with the percentage of asphalt indicated by laboratory extractions.

Tack coat shall be included in the price for other appropriate pay items.

Asphalt curb backup material will be measured in tons and will be paid for at the contract unit price per ton. This price shall include placing, tamping, and compacting.

Liquid asphalt cement, when a pay item, will be measured in tons and will be paid for at the contract unit price per ton.

Rumble strips will be measured and paid for in linear feet of shoulder where the rumble strips are actually placed and accepted, excluding the test site. This distance will be measured longitudinally along the edge of pavement with deductions for bridge decks, acceleration/deceleration lanes, surface drainage structures, and other sections where the rumble strips are not installed. This price shall be full compensation for application; disposal of waste material; and all labor, tools, equipment, and incidentals necessary to complete the work. The test site will not be measured for payment but shall be included in the unit price for rumble strip.

Liquid asphalt coating (rumble strips) will be measured and paid for in square yards as described herein. This price shall be full compensation for cleaning rumble strips prior to application of the coating; furnishing and applying coating as specified herein; and all labor, tools, equipment, and incidentals necessary to complete the work.

Saw-cut asphalt concrete pavement will be measured in linear feet for the depth specified and will be paid for at the contract unit price per foot, which price shall be full compensation for saw-cutting the asphalt pavement to the depth specified.

These prices shall include heat stabilization additive, furnishing samples, and maintaining traffic.

Payment will be made under:

Pay Item	Pay Unit
Asphalt concrete base course (Type)	Ton
Asphalt concrete (Type) (Class)	Ton
Asphalt concrete curb backup material	Ton
Liquid asphalt cement	Ton
Rumble strip (Asphalt)	Linear foot
Liquid asphalt coating (Rumble strips)	Square yard
Saw-cut asphalt concrete (depth)	Linear foot

SECTION 316—HYDRAULIC CEMENT CONCRETE PAVEMENT

316.01—Description

This work shall consist of constructing reinforced, non-reinforced, or continuously reinforced hydraulic cement concrete pavement and approach slabs composed of hydraulic cement concrete, with or without reinforcement as specified, on a prepared subgrade or base course in accordance with the requirements of these specifications and within the specified tolerances for the lines, grades, thicknesses, and cross sections shown on the plans or as established by the Engineer.

316.02—Materials

- (a) **Concrete** shall be central mixed and shall conform to the requirements specified in Table II-17 for Class A3 paving concrete except that the slump shall not be more than 2 inches for placement by the slipform method. Concrete for placement by the slipform method shall be sufficiently cohesive to prevent detrimental sloughing at the pavement edges as the forms advance. Transit mixed concrete may be furnished for use in constructing approach slabs, ramps, transitions, connections, crossovers, and other miscellaneous pavement. Aggregate used in concrete for pavement and approach slabs that are used as riding surfaces shall be nonpolishing aggregate.
- (b) **Reinforcing steel dowels, tie bars, hook bolts, and welded wire fabric** shall conform to the requirements of Section 223.
- (c) **Wide flange beams** used in the anchor slab of continuously reinforced pavement shall conform to the requirements of ASTM A36.
- (d) **Joint sealer and filler** shall conform to the requirements of Section 212.
- (e) **Load transfer devices** shall be fabricated of steel and shall be of an approved type and design.
- (f) **Curing materials** shall conform to the requirements of Section 220.

316.03—Equipment

Equipment and tools necessary for handling materials and performing the work shall be subject to the approval of the Engineer.

The Contractor shall provide the equipment and tools specified herein, or their approved equivalent, and they shall be of such capacity that the rate of placing concrete and finishing pavement will be continuous. If any piece of equipment does not have sufficient capacity to keep pace with the other operations, the Contractor shall limit the size of the batch or otherwise limit the rate of production to preclude poor workmanship or frequent delays.

- (a) **Forms:** Straight side forms shall be made of metal at least 7/32 inch in thickness and shall be furnished in sections at least 10 feet in length. Forms shall have a depth at least equal to the prescribed edge thickness of the concrete, without horizontal joints, and a base width equal to at least the depth of the forms. Flexible or curved forms of proper radius shall be used for curves with a radius of 100 feet or less. Flexible or curved forms shall be of a design acceptable to the Engineer. Forms shall be provided with adequate devices for secure placement so that when set they will withstand the impact and vibration of consolidating and finishing without visible springing or settlement. Flange braces shall extend outward on the base at least 2/3 the height of the form. Forms that are bent, twisted, or broken or that have battered top surfaces shall be removed. Repaired forms shall not be used until inspected and approved. Built-in forms shall not be used except where the total area of pavement on the project is less than 2,000 square yards. The top face of the form shall not vary from a true plane more than 1/8 inch in 10 feet, and the vertical side shall not vary from a true plane more than 1/4 inch. Forms shall have provisions for locking the ends of abutting form sections together tightly and for secure setting.
- (b) **Subgrade Machine:** The machine shall be of an approved mechanical type, capable of preparing the subgrade to within 1/4 inch of the grade shown on the plans or established by the Engineer.
- (c) **Subgrade Roller:** The roller shall be of an approved type and capable of obtaining the required density.
- (d) **Bulkheads:** Bulkheads for construction joints shall be of sufficient strength to prevent deformation of the joint and shall be constructed to permit dowels or other reinforcement to extend through the joint.
- (e) **Work Bridges:** Work bridges shall be provided by the Contractor.
- (f) **Mechanical Spreader:** The mechanical spreader shall be a self-powered, self-propelled unit capable of placing the concrete mechanically on the subgrade over the full width and depth of the pavement.

The spreader shall be equipped with a hopper or other type of spreading equipment that will distribute the concrete over the subgrade without segregation. The concrete shall not be placed directly on the subgrade from the hauling equipment except in areas where hand labor must be performed.

- (g) **Vibrators:** Vibrators for full-width vibration of concrete pavements shall be internal vibrators with multiple spuds. They may be attached to the spreader or mounted on a separate

carriage operating directly behind the spreader. The frequency of vibrators shall be at least 7,000 impulses per minute.

When spud internal vibrators, either hand operated or attached to spreaders, are used adjacent to forms, they shall have a frequency of at least 3,500 impulses per minute.

Vibration shall be controlled by the forward movement of the spreader so that vibration automatically ceases when the forward movement of the spreader is stopped.

- (h) **Spraying Equipment:** When liquid membrane-forming compound is used for curing concrete pavement, the Contractor shall provide mechanical spraying equipment mounted on movable bridges. The equipment shall be the full atomizing type equipped with a tank agitator and a gage to measure the quantity of material applied. The equipment shall be capable of continuously agitating the membrane during application.
- (i) **Concrete Saw:** When sawing joints is elected or specified, the Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions and at the required rate with a water-cooled, diamond-edged saw blade or an abrasive wheel.
- (j) **Slipform Paver:** The paver shall be designed to consolidate, screed, and float finish the freshly placed concrete in one complete pass of the machine and in a manner so that a minimum of hand finishing will be necessary to provide a dense and homogeneous pavement. The paver shall be equipped to vibrate the concrete thoroughly for the full width and depth of the strip of pavement being placed.

316.04—Procedures

- (a) **Concrete Base Course:** The subgrade or subbase upon which the base course is to be placed shall be prepared in accordance with the requirements of the applicable provisions of these Specifications for such course.

The construction of a hydraulic cement concrete base course shall conform to the requirements of these Specifications except for floating and final finishing of the surface. The surface shall be finished so that there will be no deviation of more than 1/4 inch between any two contact points when tested with a 10-foot straightedge placed parallel with the centerline. A heavy broomed texture shall be applied.

- (b) **Preparing Grade:** The subgrade shall be prepared as specified in Section 305. The course upon which the concrete pavement will rest, including the area that will support the paving equipment, shall be graded and compacted to the required profile.

Before or after side forms have been securely set to grade, the subgrade or subbase course shall be brought to the proper cross section. The finished grade shall be maintained in a smooth and compacted condition until pavement is placed.

The subgrade or subbase course shall be uniformly moist when concrete is placed. However, the method of moistening shall not be such as to form mud or pools of water.

- (c) **Placing Reinforcing Steel for Continuously Reinforced Pavement:** At each location where five or more consecutive days will elapse between placement operations, a “leave out” joint shall be installed as detailed on the plans. Longitudinal bars shall be positioned in the finished pavement within $\pm 1/2$ inch of the specified vertical position and ± 1 inch of the specified horizontal position with a cover of at least 2 inches.

Prebent deformed tie bars, Grade 40 or 60, may be used in the joint between the mainline and ramp pavement to facilitate the use of the slipform paver. Bars shall be prebent with equipment designed especially for fabricating 90-degree bends in 5/8-inch deformed bars without damage to the bars. Side forms of the slipform paver shall be designed in a manner so that the prebent tie bars can be inserted in an appropriate slot and will pass between the edge of the pavement and the inside face of the trailing forms as the paver advances.

When reinforced concrete pavement is placed in two layers, the entire width of the bottom layer shall be vibrated and struck off to such length and depth that the sheet of fabric or bar mat may be placed full length on the concrete in its final position without further manipulation. The reinforcement shall then be placed directly on the concrete, after which the top layer of concrete shall be placed, struck off, and screeded. Any portion of the bottom layer of concrete that has been placed more than 30 minutes without being covered with the top layer shall be removed and replaced with freshly mixed concrete at the Contractor’s expense. When reinforced concrete is placed in one layer, the reinforcement may be positioned in advance of concrete placement or placed by approved mechanical or vibratory means in fresh concrete after spreading.

Reinforcing steel shall be straight, and its surface condition shall conform to the requirements of Section 406.03(b).

- (d) **Setting Forms:** The foundation under forms shall be compacted to grade so that forms, when set, will be firmly in contact for their entire length and at the specified grade. Any foundation grade that is found to be low shall be filled to grade with granular 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 compacted. Imperfections or variations above grade shall be corrected by tamping or cutting as necessary.

Forms shall be set at least 500 feet in advance of concrete placement. Where local conditions make this requirement impracticable, it may be waived. After the forms have been set, the grade shall be thoroughly tamped at the inside and outside edges of the base of forms. Forms shall be staked into place with a sufficient number of pins of sufficient length for any section to hold the form at the correct line and grade. Form sections shall be tightly locked, free from play or movement. The top of the form, when tested with a 10-foot straightedge, shall not deviate more than 1/8 inch and the longitudinal axis of the vertical face shall not vary more than 1/4 inch from the straightedge. No excessive settlement or springing of forms under the finishing machine will be allowed. Forms shall be cleaned and oiled prior to concrete placement.

The alignment and grade elevation of forms shall be checked and corrections made by the Contractor immediately before concrete placement. If any form has been disturbed or any grade has become unstable, the form shall be reset and rechecked.

- (e) **Placing Concrete:** Concrete shall be placed on the grade in a quantity that will provide a uniform and adequate supply for the finishing equipment. Spreading shall be accomplished

with a mechanical spreader. Necessary hand spreading shall be performed using square-faced shovels. The use of rakes or hoes will not be permitted. Workers shall not be allowed to walk in the freshly mixed concrete with boots or shoes coated with soil or foreign substances.

Where concrete is placed adjoining a previously constructed lane and mechanical equipment will be operated from the existing lane, the concrete in that lane shall have attained a modulus of rupture strength of at least 450 pounds per square inch. Test specimens for this purpose shall conform to the requirements of ASTM C31 and shall be tested in accordance with the requirements of ASTM C293. Equipment that will damage the surface of the existing pavement will not be permitted.

Concrete shall be thoroughly consolidated against forms and joint assemblies by means of full-width vibration. Vibrators will not be permitted to come in contact with a joint assembly, reinforcement, or side forms. The vibrator shall not be operated for more than 15 seconds in any one location. When fabric or bar mat reinforcement is placed by mechanical equipment that uses vibration or a tamping action, other vibratory equipment may be eliminated except in areas adjacent to side forms.

Concrete shall be placed as close to expansion and contraction joints as is possible without disturbing the joints. Concrete shall be placed over and around dowels in a manner so that dowels are fully embedded without displacement.

Concrete for continuously reinforced pavement shall be placed through the openings in the steel in one lift and vibrated with an internal vibrator for the entire width and depth. Special attention shall be given to the consolidation of the concrete in the immediate vicinity of construction joints and other areas where the performance of vibrators mounted on the paving equipment is questionable.

Following concrete placement, concrete shall be struck off to conform to the cross section shown on the plans and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement shall conform to the tolerances specified herein for the elevation and grade shown on the plans or as established by the Engineer.

If concrete operations are permitted to extend after sunset, adequate lighting shall be provided.

- (f) **Test Specimens:** The Contractor shall furnish the concrete necessary for casting test beams in accordance with the requirements of (o) herein. Beams shall be cured by a designated method as specified for the pavement in accordance with the requirements of ASTM C31.
- (g) **Jointed Pavement:** Joints shall be installed in a manner and at such time to prevent random or uncontrolled cracking. If random or uncontrolled cracking occurs, sufficient concrete shall be removed and replaced on each side of the cracking to form a slab at least 10 feet long. Transverse construction joints shall be constructed at each end of the slab in accordance with the requirements of the applicable provisions of 4. herein.
 1. **Longitudinal joints:** Deformed tie bars of the specified length, size, spacing, and material shall be placed perpendicular to the longitudinal joints. They shall be placed by approved mechanical equipment and rigidly secured by chairs or other approved supports to prevent displacement or by the insertion of bars with an approved hand tool.

When adjacent lanes of pavement are constructed separately, approved two-piece connectors shall be used.

Longitudinal joints shall be sawed, formed, or created using a strip insert. Longitudinal center joints shall be installed in a manner so that full contact is made at intersections with transverse joints.

- a. **Formed joints:** Formed joints shall consist of a groove extending downward from, and normal to, the surface of the pavement and shall be formed by an approved nonmetallic or removable device that consistently demonstrates its ability to produce in fresh concrete a joint having the dimensions and line indicated on the plans. The groove shall be sealed with a premolded or poured joint material as required.
- b. **Strip insert joints:** A longitudinal weakened plane joint may be furnished at traffic lane lines in multilane monolithic concrete pavement in lieu of forming or sawing such joints. Strip insert joints shall be formed by placing a continuous strip of plastic or other approved material. The insert strip shall be of sufficient width to form a weakened plane to the depth shown on the plans. The thickness of the insert material shall be at least 20 mils. Strip insert joints shall not be sawed.

The insert strip shall be inserted with a mechanical device that places the material in a continuous strip. Splices will be permitted provided they are effective in maintaining the continuity of the insert strip. The top edge of the insert strip shall be positioned flush with the finished surface. The insert strip shall not be deformed from a vertical position during installation or in subsequent finishing operations performed on the concrete. The alignment of the finished joint shall be uniformly parallel with the centerline of the pavement and free from local irregularities in alignment that are more than 1/2 inch in 10 feet. The mechanical installation device shall vibrate the concrete during the insertion of the strip in a manner to cause the disturbed concrete to return evenly along the sides of the strip without segregating or developing voids.

If the Contractor is unable to furnish a satisfactory strip insert joint consistently, he shall, upon being notified by the Engineer, discontinue furnishing such joints and furnish other approved formed or sawed joints without additional compensation.

- c. **Sawed joints:** Longitudinal sawed joints shall be cut with approved concrete saws. Suitable guidelines or devices shall be used to ensure cutting the longitudinal joint on the true line as shown as soon as the concrete has hardened sufficiently to permit sawing without chipping, spalling, or tearing. Concrete faces of the saw cut shall be protected from drying until the end of the specified curing period. Sawed joints shall be thoroughly cleaned and dried prior to being sealed.
2. **Transverse expansion joints:** Transverse expansion joints shall be formed in accordance with the requirements of 1.a. herein and shall be sealed using Type D material. Expansion joint filler shall be continuous from form to form, shaped to the subgrade. Preformed joint filler shall be furnished in lengths equal to the pavement width or the width of one lane. Damaged or repaired joint filler shall not be used.

Expansion joint filler shall be held in a position perpendicular to the subgrade. An approved installing bar, or other device, shall be used, if required, to secure preformed joint filler at the proper grade and alignment during placing and finishing of concrete. Finished joints shall not deviate more than 1/4 inch in the horizontal alignment from a straight line. If joint filler is assembled in sections, there shall be no offsets between adjacent units.

3. **Transverse contraction joints:** Transverse contraction joints shall consist of planes of weakness created by cutting grooves in the surface of the pavement and, when shown on the plans, shall include load transfer assemblies.

Edges of concrete adjacent to the joint may be rounded or beveled to a radius or length approved by the Engineer. Any joint having an insufficient opening shall be resawed or ground to the proper size. Where a joint opening is larger than that specified, the Contractor may be required to build up the joint with epoxy mortar or to furnish a larger size seal as determined by the Engineer. The cost of any such additional work or material shall be borne by the Contractor.

4. **Transverse construction joints:**

- a. **Jointed pavement:** Unless specified expansion joints occur at the same points, transverse construction joints shall be constructed at the end of each day's work or when there is an interruption of more than 30 minutes in the concreting operations. A transverse construction joint shall not be constructed 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, the excess concrete back to the last preceding joint shall be removed and disposed of as directed. An approved header board, cut to the required cross section, shall be used to form joints. Deformed dowel bars shall be used in transverse construction joints whose location does not coincide with the specified location of a transverse expansion or contraction joint.
- b. **Continuously reinforced concrete pavement:** Transverse construction joints shall be formed by the use of an approved header board in accordance with the requirements of 4.a. herein. The header shall consist of two sections, one being placed above and one being placed below the reinforcing mat, and shall be furnished with openings to accommodate the longitudinal steel and additional reinforcement required.

At any location where a "leave out" is necessary for a detour, at least 100 feet shall be maintained between transverse construction joints.

5. **Load transfer devices:** Plain dowels shall be held in position parallel with the surface and centerline of the slab by a metal device that is left in the pavement.

The entire free end of each dowel shall be painted with one coat of approved paint. When the paint has dried and immediately before dowels are placed in position, the free end shall be thoroughly coated with an approved lubricant. A metal or plastic dowel cap of approved design to cover 2 inches, $\pm 1/4$ inch, of the dowel, with a closed end, and with a suitable stop to hold the end of the sleeve at least 1 inch from the end of the dowel bar shall be furnished for each dowel bar used in expansion joints. Caps

or sleeves shall fit the dowel bar tightly, and the closed end shall be mortartight. Dowels, plastic coated in accordance with the requirements of Federal Specification L-C-530 C or epoxy coated in accordance with the requirements of ASTM A775, may be used in lieu of painted and lubricated dowel bars.

In lieu of using dowel assemblies at contraction joints, dowel bars may be placed in the full thickness of pavement by an approved device.

6. **Isolation joints at structures:** Isolation joints shall be formed by placing a strip of 1/2-inch preformed expansion joint filler around each structure that extends into or through the pavement before concrete is placed at that location.
- (h) **Final Striking Off, Consolidating, and Finishing:** The sequence of operations shall be as follows: (1) striking off, (2) consolidating, (3) floating, (4) removing laitance, (5) straightening, and (6) finishing. If the application of moisture to the surface is permitted, it shall be applied as a fog spray by means of approved spray equipment.
1. **Finishing at joints:** Concrete adjacent to joints shall be mechanically vibrated to prevent voids and segregation from occurring against the joint material. Concrete under and around load transfer devices, joint assembly units, and other features designed to extend into the pavement shall also be mechanically vibrated.
 - a. **Machine finishing:** Concrete shall be spread as soon as placed, struck off, and screeded by an approved finishing machine. Vibration for the full width of the paving slabs shall be provided in accordance with the requirements of Section 316.03(g). The machine shall be operated over each area of pavement as many times and at such intervals as are necessary to result in proper consolidation and develop a surface of uniform texture. Excessive manipulation of a given area shall be avoided.

During the first pass of the finishing machine, a uniform roll of concrete shall be maintained ahead of the front screed for its entire length.

If a uniform and satisfactory density of concrete is not obtained at joints, along forms, at structures, and throughout the pavement, the Contractor will be required to furnish equipment and use methods that will produce pavement conforming to the requirements specified herein.

- b. **Hand finishing:** Hand finishing will be permitted only under the following conditions: (1) to finish concrete already deposited on the grade in the event of a break down of mechanical equipment; and (2) to finish narrow widths, approach slabs, or other areas of irregular dimensions where the operation of mechanical equipment is impractical.

Concrete shall be struck off as it is placed and screeded with an approved portable screed. If reinforcement is required, the bottom of concrete shall be screeded prior to placement of reinforcement.

Consolidation shall be attained by the use of an approved vibrator or other approved equipment.

Hand finishing shall be kept to the absolute minimum necessary to attain a surface that has a uniform texture, is true to the approximate grade and cross section, and has a closed surface.

2. **Floating:** After concrete has been struck off and consolidated, it shall be further smoothed and made true by means of a float using one of the following methods as specified or permitted:

- a. **Mechanical method:** A mechanical float shall be adjusted so that its full length will be in continuous contact with the surface of the pavement.

If necessary, long-handled floats having blades at least 5 feet in length and 6 inches in width may be used to smooth and fill in open-textured areas in the pavement. Long-handled floats shall not be used to float the entire surface of the pavement in lieu of, or supplementing, the prescribed method of floating.

- b. **Hand method:** This method will be permitted only in those instances specified in 1.b. herein. Following strike off by an approved screed, concrete shall be smoothed with a darby to level raised spots or fill depressions. Long-handled floats or hand floats of wood or metal, as the area dictates, may be used in lieu of darbies to smooth and level the concrete surface. Excessive bleed water shall be wasted over the side forms after each pass of the float.

3. **Straightedge testing and surface correction:** After floating has been completed and excess water removed, but while concrete is still fresh, the surface of the concrete shall be tested for trueness with a 10-foot straightedge. The Contractor shall furnish and use an accurate 10-foot straightedge swung from handles 3 feet longer than 1/2 the width of the slab. The straightedge shall be held in contact with the surface in successive positions parallel with the pavement centerline, and the entire area shall be gone over from one side of the slab to the other as necessary. Advancement along the pavement shall be in successive stages of not more than 1/2 the length of the straightedge. Depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated, refinished, and retested. High areas shall be cut down and refinished. Special attention shall be given to ensure that the surface across joints conforms to the requirements for smoothness. Straightedge testing and surface corrections shall continue until the entire surface is free from observable departures from the straightedge and the slab conforms to the required grade and cross section.

4. **Final finish (texture):** Prior to grooving, multi-ply damp fabric shall be dragged over the pavement surface to provide a gritty texture on ridges between grooves. The roadway pavement riding surface shall be textured with (1) uniformly pronounced grooves approximately 1/8 inch in depth and 1/8 inch in width on approximately 3/4-inch centers and transverse to the pavement centerline, or (2) a combination of uniformly pronounced grooves approximately 1/8 inch in depth and 1/8 inch in width on approximately 3/4-inch centers and longitudinal to the pavement centerline and additional grooves 1/8 inch in depth and 1/8 inch in width on grooves 1/8 inch in depth and 1/8 inch in width on approximately 3-inch centers and transverse to the pavement center line.

- (i) **Stenciling Station Numbers and Dates:** Before concrete takes its final set and after finishing operations are completed, the Contractor shall stencil station numbers and dates into the

pavement in accordance with the standard drawings. The dies for numbering and dating will be furnished by and remain the property of the Department. Dies or numerals lost or damaged by the Contractor shall be replaced at his expense.

(j) **Curing:**

1. **Membrane-forming compounds:** The entire surface of the pavement shall be sprayed uniformly with a white-pigmented membrane-forming compound immediately following the texturing operation.

The compound shall be applied under constant pressure at the rate of 100 to 150 square feet per gallon by mechanical sprayers mounted on movable bridges. On textured surfaces, the rate shall be as close to 100 square feet as possible. Application shall be such that an even, continuous membrane is produced on the concrete surface. At the time of use, the compound shall be in a thoroughly mixed condition, with the pigment uniformly dispersed throughout the vehicle. During application, the compound shall be continuously and effectively agitated. Hand spraying of odd widths or shapes and concrete surfaces exposed by removing forms and sawing joints will be permitted.

The membrane shall harden 30 minutes after application. Personnel and equipment shall be kept off the freshly applied material to prevent damage to the seal. If the membrane becomes damaged within the initial 72 hours, damaged portions shall be repaired immediately with additional compound.

Upon removal of side forms, sides of exposed slabs shall be protected immediately to provide a curing treatment equal to that provided for the surface.

If the slipform method of paving is used, edges of pavement shall be cured in the same manner and at the same time as the surface.

2. **PE film:** When PE film is used for curing, it shall be white. However, from November 1 to April 1, clear or opaque PE film will be permitted.
 3. **Protection in cold weather:** The Contractor shall prevent the temperature at the surface of the concrete from falling below 40 degrees F during the first 72 hours immediately following concrete placement. Protective material shall be left in place for an additional 48 hours if freezing air temperatures are expected to continue. Such protection shall be furnished in addition to the curing material required elsewhere in these specifications. The Contractor shall be responsible for the quality of the concrete placed during cold weather. Concrete damaged by the action of frost or by freezing shall be removed and replaced at the Contractor's expense.
 4. **Curing in hot, low-humidity, or windy weather:** Care shall be taken in hot, dry, or windy weather to protect the concrete from shrinkage cracking by applying the curing medium at the earliest possible time after finishing operations and after the sheen has disappeared from the surface of the pavement.
- (k) **Surface Test:** As soon as concrete has hardened sufficiently, the pavement surface will be tested by the Engineer with a 10-foot straightedge. Areas showing high spots of more than 3/16 inch on mainline pavement and approach slabs but not exceeding 1/2 inch in 10 feet shall be marked and, after the concrete has attained the design compressive strength, cut

down with an approved cutting tool to an elevation where the area or spot will not show surface deviations in excess of 3/16 inch. Areas showing high spots of more than 3/8 inch on ramps when tested with a 10-foot straightedge shall be marked and, after the concrete has attained the design compressive strength, corrected to within the 3/8-inch tolerance by removing and replacing or by cutting as specified herein. If the slipform method of paving is used, a straightedge tolerance of $\pm 1/4$ inch in 10 feet will be permitted for the area within 6 inches of the slipformed edge except for pavement adjacent to connections and ramps. Equipment for cutting shall be designed to cut the surface of the pavement in a longitudinal direction parallel with the centerline and in a uniform planing action. However, the cutting operation shall not produce a polished pavement surface. The equipment shall be adjustable so as to vary the depth of the cut as required. Bush hammering, rubbing with carborundum stone, or hand grinding will not be permitted. Where the departure from the specified cross section exceeds 0.20 percent on mainline pavement, the pavement shall be removed and replaced by and at the expense of the Contractor.

- (l) **Removing Forms:** Forms shall not be removed from freshly placed concrete until it has set for at least 12 hours. Forms shall be removed carefully to avoid damage to the pavement. After forms are removed, the sides of the slab shall be cured as specified by one of the methods described herein. Major honeycombed areas will be considered defective work and shall be removed and replaced. Any area of section removed shall be not less than 10 feet in length or less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than 10 feet in length shall also be removed and replaced.
- (m) **Sealing Joints:** Before pavement is opened to traffic, including the Contractor's equipment, and as soon after completion of the curing period as practicable, joints required to be sealed shall be filled with joint-sealing material. Just prior to sealing or resealing, each joint shall be thoroughly cleaned by brushing, routing, sawing, grinding, blast cleaning, or any combination thereof to eliminate oil, grease, existing joint material, membrane-forming compound, laitance, protrusions or hardened concrete, dirt, or other foreign material that cannot be removed by means of compressed air to a depth at which the sealer and backup material, if required, are to be installed. Dust and loose material shall be removed from the joint with oil-free and water-free compressed air delivered at a minimum of 120 cubic feet of air per minute and a nozzle pressure of at least 90 pounds per square inch. Existing joint material extending outside the joint shall be removed.

Joint material shall be installed in accordance with the manufacturer's recommendations. However, in the absence of specific recommendations or plan details, the following provisions shall apply.

1. Preformed seals shall be installed by machines that are designed especially for such installation and shall not damage the seal. Types A and D material shall be installed by machine. The seal shall be installed with its vertical axis parallel with the interfaces of the joint.
2. The method of installing preformed seals shall be such that the seal is not stretched more than 5 percent of the length of the joint.

The method of installation shall be checked for stretching, using transverse joint sealer. The check shall consist of installing sealer in five joints, the full width of the pavement, and removing the sealer immediately after installation and checking the length.

If the measured length of any of the five sealers is less than 95 percent of the minimum theoretical length required to seal the joint, the installation method shall be modified so that stretching greater than 5 percent no longer occurs. Once sealing operations have started, 1 joint per every 100 shall be removed and checked for stretch in excess of 5 percent. If a stretched condition is detected, the joint sealers on either side shall be removed until the condition disappears. Affected joints shall be resealed in a satisfactory manner at the Contractor's expense.

3. For rounded or beveled joints, seal or sealant shall be installed in a depth of at least 1/8 but not more than 1/4 inch below the bottom edge of the rounding or bevel. For joints with vertical sides, seals or sealant shall be installed at a depth of 1/4 inch, $\pm 1/16$ inch, below the level of the pavement surface.
4. Hot-poured sealer shall be applied to a completely dry joint. The ambient air temperature shall not be below 40 degrees F. The joint shall be filled with hot-poured sealer by means of a sealing device that will not cause air to be entrapped in the joint. Sufficient passes shall be made to achieve the filled joint requirement.
5. Material for hot-poured sealer shall be stirred during heating so that localized overheating does not occur.
6. Sealer shall not be placed directly on the filler but shall be prevented from bonding to the filler by a carefully placed strip of waxed or silicone paper, plastic tape, aluminum foil, or other suitable material placed over the filler before sealer is applied. Masking tape or other means shall be used to avoid spilling sealer onto adjacent concrete surfaces. Excess sealer on such surfaces shall be cleaned off before the material has set without damaging the material in the joint.
7. Silicone sealer shall not be applied when the air temperature is below 40 degrees F. Sealer shall fill the joint and shall be applied inside the joint from the bottom up by means of an application device that will not cause air to be entrapped. Immediately after application, sealer shall be tooled to form a recess below the pavement surface in accordance with the standard drawings. The use of soap, water, or oil as a tooling aid will not be permitted. Primer, if used with silicone sealer, shall be applied to the joint faces prior to installation of backup material. Backup material shall be approximately 25 percent larger than the joint width and shall be installed in the joint such that it is not displaced during the sealing application.

Sealing material shall be applied in a manner so that it will not be spilled on the exposed surfaces of the concrete. Excess material on the surface of the concrete pavement shall be removed immediately, and the pavement surface cleaned. The use of sand or similar material as a cover for the seal will not be permitted.

- (n) **Protecting Pavement:** The Contractor shall protect the pavement and its appurtenances against public traffic and traffic caused by his employees and agents. This shall include furnishing watchpersons and flaggers to direct traffic and erecting and maintaining warning signs, lights, pavement bridges, or crossovers.

In order that the concrete may be properly protected against the effects of rain before it has attained final set, the Contractor shall have covering material available at the work site, such as burlap, cotton mats, curing paper, or plastic sheeting.

If the slipform method of paving is used, the Contractor shall also have material available at all times for protecting the edges of unhardened concrete. Protective materials shall consist of standard metal forms or wood planks having a nominal thickness of at least 2 inches and a nominal width of at least the thickness of the pavement at its edges.

When rain appears imminent, concrete placement operations shall be halted and available personnel shall assist in covering the surface of unhardened concrete.

A layer of coarse burlap shall be applied to the surface of fresh concrete prior to the application of PE film or other protective coverings that tend to “wipe out” or reduce the texture upon contact.

The Engineer will carefully consider any damage to the pavement occurring prior to final acceptance and may allow the Contractor to repair such damage or require the damaged pavement to be replaced.

- (o) **Opening to Traffic:** Pavement shall not be opened to traffic until specimen beams conforming to the requirements of (f) herein have attained a modulus of rupture strength of 600 pounds per square inch when tested by the center point loading method in accordance with the requirements of ASTM C293. In the absence of such tests, pavement shall not be opened to traffic until 14 days after concrete is placed. Prior to opening to traffic, pavement shall be cleaned and joints sealed and trimmed.
- (p) **Saw-Cut Hydraulic Cement Concrete Pavement:** This work shall consist of saw-cutting the existing hydraulic cement concrete pavement to a depth shown on the plans and as directed by the Engineer.

316.05—Thickness and Finished Grade Tolerances

The thickness of pavement will be determined by average caliper measurements of cores taken therefrom in accordance with the requirements of VTM-26.

Areas found to be deficient in thickness by more than 1.00 inch will be evaluated by the Engineer, and if in his judgment the deficient areas warrant removal, they shall be removed and replaced with concrete of the thickness specified on the plans. The deficient area shall be the product of the full width of the slab or lane of pavement multiplied by the sum of the distances in each direction from the deficient core along the centerline of the pavement to the first actual cores found not deficient in thickness by more than 1.00 inch.

The Contractor shall fill test holes with the same type of concrete as in the pavement.

After placement of the final pavement layer, finished grade elevations shall be within ± 0.04 foot of the elevations indicated in the plans, unless otherwise specified, provided that the actual cross slope does not vary more than 0.20 percent from the design cross slope indicated in the plans and the pavement thickness conforms to the thickness tolerances specified herein.

If determined by the Engineer that either the finished grade elevations or cross slope exceeds the tolerances specified, the Contractor shall submit to the Engineer for approval a plan of corrective action.

Finished grades shall be constructed to the proposed cross sections, and cross slopes shall be constructed to the proposed typical section slopes indicated on the plans. Areas found to deviate from the indicated cross slopes by 0.20 percent or more shall be corrected or replaced by the Contractor at no additional cost to the Department.

316.06—Measurement and Payment

Hydraulic cement concrete pavement will be measured in square yards of concrete pavement, complete-in-place, and will be paid for at the contract unit price per square yard. This price shall include furnishing and placing materials, including dowels, reinforcement, and joint material, provided that for any pavement found deficient in average thickness, as described in VTM-26, by more than 0.20 inch but not more than 1.00 inch only the reduced price stated herein will be paid. The width of measurement will be the width of the pavement shown on the typical cross section of the plans, additional widening where called for, or as otherwise directed in writing by the Engineer. The length will be measured horizontally along the centerline of each roadway or ramp.

Concrete entrance pavement, concrete launching ramps, and anchor slabs will be measured in square yards of surface area, complete-in-place, and will be paid for at the contract unit price per square yard.

Bridge approach slabs, when a pay item, will be measured in cubic yards of concrete and pounds of reinforcing steel, complete-in-place, and will be paid for at the contract unit price per cubic yard of concrete and per pound of reinforcing steel.

Bridge approach expansion joints will be measured in linear feet of transverse measure, complete-in-place, and will be paid for at the contract unit price per linear foot. This price shall include subslab excavating and furnishing and placing materials.

No additional payment over the contract unit price will be made for any pavement that has an average thickness in excess of that specified on the plans.

Resealing joints, when a pay item, will be paid for at the contract unit price per linear foot. This price shall include joint preparation, furnishing and placing sealer, and removing and disposing of debris.

Saw-cut hydraulic cement concrete pavement will be measured in feet for the depth specified and will be paid for at the contract unit price per foot, which price shall be full compensation for saw-cutting the hydraulic cement concrete pavement to the depth specified.

Price adjustments: Where the average thickness of pavement is deficient by more than 0.20 but not more than 1.00 inch, payment will be made at an adjusted price as specified by the following:

Deficiency in Thickness (in)	% of Contract Unit Price Allowed
0.00–0.20	100
0.21–0.30	80
0.31–0.40	72
0.41–0.50	68
0.51–0.75	57
0.76–1.00	50

316.06

When the thickness of pavement is deficient by more than 1.00 inch and the Engineer determines that the area of such deficiency should not be removed and replaced, there will be no payment for the area retained.

Payment will be made under:

Pay Item	Pay Unit
Hydraulic cement base course (Depth)	Square yard
Plain hydraulic cement concrete pavement (Depth)	Square yard
Reinforced hydraulic cement concrete pavement (Depth)	Square yard
Continuously reinforced hydraulic cement concrete pavement (Depth)	Square yard
Concrete, Class A4, bridge approach slab	Cubic yard
Reinforcing steel, bridge approach slab	Pound
Bridge approach expansion joint	Linear foot
Concrete entrance pavement (Depth)	Square yard
Concrete launching ramp (Standard)	Square yard
Anchor slabs (Type)	Square yard
Resealing (Type) joints (Material)	Linear foot
Saw-cut hydraulic cement concrete pavement (depth)	Linear foot

SECTION 317— STONE MATRIX ASPHALT CONCRETE PAVEMENT

317.01—Description

This specification covers the furnishing, installation, and acceptance criteria for stone matrix asphalt (SMA) concrete pavement.

317.02—Materials

- (a) **Coarse aggregate** shall conform to the requirements of Section 248.02(a):
- (b) **Fine aggregate** shall conform to the requirements of Section 248.02(b).
- (c) **Asphalt binder** shall conform to the requirements of Section 248.02(c).
- (d) **Mineral filler** shall conform to the requirements of Section 248.02(d).
- (e) **Fiber additive** shall conform to the requirements of Section 248.02(e).

317.03—Composition of SMA Mixture

This section shall conform to the requirements of Section 248.

317.04—Acceptance

This section shall conform to the requirements of Section 248.

317.05—SMA Mixing Plant

- (a) **Mineral filler handling** shall be in accordance with the requirements of Section 248.05(a).
- (b) **Fiber addition** shall be in accordance with the requirements of Section 248.05(b).
- (c) **Hot-mixture storage** shall conform to the requirements of Section 248.05(c).
- (d) **Mixing temperatures** shall conform to the requirements of Section 248.05(d).

317.06—Weather Restrictions

SMA mixture shall be placed only when the ambient and surface temperatures are 50 degrees F or above.

317.07—Placing and Finishing

The mixture temperature in the truck shall not be less than 300 degrees F for mixtures containing PG 70–22 and 310 degrees F for mixtures containing PG 76–22. The temperature immediately behind the screed shall not be less than 290 degrees F for mixtures containing PG 70–22 and shall be not less than 300 degrees F for mixtures containing PG 76–22.

A continuous paving operation that provides for constant steady movement of the paver shall be maintained. In the event that excessive stop and go of the paver is occurring, production and laydown of the mixture shall be stopped until the Contractor has made satisfactory changes in the production, hauling, and placement operations resulting in a constant steady movement of the paver.

A Material Transfer Vehicle (MTV) shall be used during the placement of SMA mixes. The paving operation shall have remixing capability in either the MTV or a paver-mounted hopper to produce uniform, nonsegregated mix with uniform temperature. The MTV and paver combination shall have a minimum storage capacity of 15 tons. In the event of a break down, paving shall be discontinued and no more material shall be shipped from the hot-mix plant.

317.08—Compaction

Immediately after the mixture has been spread and struck off, it shall be thoroughly and uniformly compacted by rolling. Rolling shall be accomplished with steel wheel roller(s) with a minimum weight of 10 tons. A minimum of three rollers shall be available at all times for compaction and/or finish rolling.

To minimize coarse aggregate fracture/breakage in the aggregate skeleton of SMA mixes, the use of vibratory rollers on SMA should be approached with caution. If a vibratory roller is used, the mat

shall receive not more than three vibratory passes. The roller shall use only the highest frequency and lowest amplitude setting.

Rolling procedures shall be adjusted to provide the specified pavement density. Rollers shall move at a uniform speed not to exceed 3 mph with the drive wheel nearest the paver. Rolling shall be continued until all roller marks are eliminated and the minimum density has been obtained. The Contractor shall monitor density during the compaction process by use of nuclear density gages to ensure that the minimum required compaction is being obtained. During the trial section, The Department will randomly select 3 plugs or cores locations to determine the in-place density in accordance to VTM-22.

To prevent adhesion of the mixture to the rollers, the wheels shall be kept properly moistened with water that may be mixed with very small quantities of detergent or other approved material.

The Contractor shall perform acceptance testing for density for each day's production by obtaining one sawed specimen, 4 by 4 inch, or a 4-inch-diameter core at three stratified random locations specified by the Engineer. The three cores or plugs shall be obtained and the in-place density determined in accordance with the requirements of VTM-22. Core locations shall be numbered sequentially per roadway, marked on the pavement, filled with SMA mixture, and compacted prior to completion of each day of production. The average density of the three cores as determined in accordance with the requirements of VTM-22 shall be 94 to 98 percent for 100 percent pay. Cores or plugs shall be bulked in the presence of the Department. The Department reserves the right to have the cores or plugs bulked on the project site. The payment for density will be in accordance with the following:

Payment Schedule

Density Achieved	% of Payment
More than 98.0	97
94.0 to 98.0	100
92.0 to 93.9	85
90.0 to 91.9	65
Less than 90.0	Remove and replace

317.09—Trial Section

A trial section(s), a maximum of 300 tons, shall be constructed at a site approved by the Engineer at least 1 week prior to, but not more than 30 days prior to, roadway construction to examine the mixing plant process control, mixture draindown characteristics, placement procedures, SMA surface appearance, and compaction patterns and to calibrate the nuclear density device. In addition, the percentage of flat and elongated particles will be calculated on the SMA material produced for the trial section in accordance with the requirements of VTM-121 and compared to the maximum limits specified in the Coarse Aggregate Table in Section 248.02(a). A passing F&E sample is required for acceptance of the trial section. Acceptance of trial section shall be in accordance to section 317.04.

The material placed in the trial sections shall be placed at the specified application rate using the same equipment that will be used during production.

317.10—Prepaving Conference

Prior to the start of production, the Department will hold a prepaving conference. Those attending shall include the Contractor's production supervisor and laydown supervisor, a representative of the fiber supplier, and a representative of the asphalt binder supplier.

317.11—Measurement and Payment

Stone matrix asphalt will be measured in tons and paid for at the contract unit price per ton for the mix type specified, which price shall include all materials, additives, and equipment as described herein.

The initial trial section will be paid for at the contract unit price for the mix type specified. With the approval of the Engineer, up to one additional trial section of the mix type specified will be paid for at the contract unit price. The Department will pay for a maximum of two trial sections at the contract unit price. If more than two trial sections are needed, the Department and Contractor shall negotiate the price based on a reduced percentage of the contract unit price, and the subsequent trial sections shall be constructed at sites approved by the Engineer.

Payment will be made under:

Pay Item	Pay Unit
Stone matrix asphalt, (Type) (Class)	Ton

Division IV
BRIDGES AND STRUCTURES

SECTION 401—STRUCTURE EXCAVATION

401.01—Description

This work shall consist of excavating and backfilling or disposing of material necessary for constructing substructures and superstructures of new bridges and altering existing bridges in accordance with the requirements of these specifications and in conformity with the lines and grades shown on the plans or as established by the Engineer.

401.02—Materials

- (a) **Backfill** shall be approved by the Engineer and shall be free from large or frozen lumps, wood, or rocks more than 3 inches in their greatest dimension or other extraneous material. Porous backfill shall conform to the requirements of Section 204.02(c).
- (b) **Pipe underdrains** shall conform to the requirements of Section 232.02.

401.03—Procedures

Excavated material shall generally be used for backfilling and constructing embankments over and around the structure. Surplus or unsuitable material shall be disposed of in a place and manner such that it will not affect or re-enter streams or otherwise impair the hydraulic efficiency or appearance of the structure or any part of the roadway.

Where practicable, substructures shall be constructed in open excavation and, where necessary, the excavation shall be sheeted, shored, braced, or protected by other means. If footings can be placed in the dry without the use of sheeting or cofferdams, forms may be omitted with the approval of the Engineer and the entire excavation filled with concrete to the required elevation of the top of the footing. When forms are eliminated, measurement and payment for structure excavation and concrete will be on a plan quantity basis wherein no adjustments will be made.

Unless tremie placement of concrete is specified, foundations for footings shall be kept free from standing or surface water until concrete and backfill operations have been completed. However, if the foundation is rock or the footing is supported on piles, other than for shelf abutments, dewatering need be performed only during concrete and backfill operations.

- (a) **Preserving the Channel:** Excavation shall not be performed outside caissons, cribs, cofferdams, or sheet piles. The natural streambed adjacent to the structure shall not be disturbed. Material deposited in the stream area because of the Contractor's operations shall be removed, and the stream area shall be freed from obstructions caused by the Contractor's operations.

Prior to beginning work, the Contractor shall submit a plan that shall include the specific location of temporary structures or other obstructions that will constrict the stream flow, a description of construction activities that will contribute to constricting the stream flow, the dimensions and number of temporary structures and constrictions that are to be placed in the stream at any one time, and a dimensional elevation view of the stream and proposed temporary structures and constrictions.

- (b) **Depths of Foundations:** Elevations denoting the bottom of footings shown on the plans shall be considered approximate only. Foundations shall not be considered satisfactory until approved by the Engineer.

When requested, the Contractor shall explore foundations by rod soundings or drillings to determine, to the satisfaction of the Engineer, the adequacy for the foundations to support the structure. If explorations indicate that satisfactory foundations can be obtained, variations from plan depths to foundations of open column abutments and solid or column piers shall be made only by adjusting stem lengths. Footing depths shown on the plans shall be considered minimum depths. Plan depths of concrete for footings may be increased not more than 24 inches at points of local irregularity over solid rock foundations.

Variations from plan depths to foundations of solid or deep curtain-wall abutments shall be made only by adjusting the depths of footings. Plan depths shall be considered minimum depths and shall not be exceeded by more than 3 feet.

If explorations reveal that foundations or subfoundations are inadequate for the structure, or are not within the limits of permissible variation from the bottom of footing elevations, the Engineer shall be consulted for instructions for further action or redesign.

- (c) **Preparing Foundations for Footings:** Hard foundation material shall be freed from loose material; cleaned; and cut to a firm surface, either level, stepped, or serrated as directed by the Engineer. Seams shall be cleaned out and filled with concrete as directed by the Engineer.

When concrete is to rest on an excavated surface other than rock, the bottom of the excavation shall not be disturbed. The final removal of foundation material to grade shall not be performed until just prior to concrete placement.

When the elevation of the bottom of a footing is above the level of the original ground, the footing shall not be placed until the approach embankment has been placed and compacted to the elevation of the top of the footing and excavation has been performed through the embankment to the elevation of the bottom of the footing. When a footing is to be placed over material subject to movement because of pressure from overlying or adjacent fill, the footing or piles for the footing shall not be placed until after the fill has been placed and compacted. Excavation for shelf abutment footings shall be limited to a perimeter extending not more than 18 inches outside the neat lines at the bottom of the footing.

When the material on which a foundation is to be placed using piles is declared unsatisfactory by the Engineer, the excavation shall be undercut for a depth of 6 to 12 inches as directed and backfilled with crusher run aggregate, select borrow, or other material approved by the Engineer.

- (d) **Holes for Drilled-In Caissons:** Foundation bearing areas shall be cut to an approximately level surface except that they may be stepped or serrated on hard rock. If material is encountered that is not sufficiently cohesive to maintain the proper diameter of the hole, casing shall be used.
- (e) **Cofferdams:** Cofferdams for foundation construction shall be as watertight as practicable and carried to a depth that will allow them to function properly without displacement. The interior dimensions of cofferdams shall be such as to give sufficient clearance for the con-

struction of forms and inspection of their exteriors and permit pumping from outside the forms. Cofferdams that are tilted or moved laterally during sinking shall be realigned to provide the required clearance.

If conditions are encountered that render it impracticable to dewater the foundation, the Contractor may be required to construct a concrete foundation seal of the dimensions necessary to ensure that the balance of the concrete can be placed in the dry. When weighted cofferdams are employed and the weight is used to overcome the hydrostatic pressure acting against the bottom of the foundation seal, anchorage, such as dowels or keys, shall be provided to transfer the entire weight of the cofferdam into the foundation seal. Cofferdams that are to remain in place shall be ported at the low water level.

Cofferdams shall be constructed in a manner to prevent damage to fresh concrete from a sudden rising of the stream and prevent damage to the foundation by erosion. Timber or bracing left in cofferdams shall not extend into the substructure concrete.

Cofferdams, including sheeting and bracing, shall be removed after completion of the substructure in a manner that will not disturb or damage the finished concrete.

- (f) **Pumping:** Pumping from the interior of a foundation enclosure shall be performed in a manner to preclude the possibility of water moving through any fresh concrete. Pumping will not be permitted during concrete placement or for at least 24 hours thereafter unless it is performed from a suitable sump separated from the concrete work.
- (g) **Protecting Existing Structures or Utilities:** When foundations are located such that excavation may endanger or interfere with an existing structure or utility, the location of bracing and method of protection shall be subject to approval by the owner of the structure or utility.
- (h) **Inspection:** After each excavation has been completed, the Contractor shall notify the Engineer and request his inspection and approval. Concrete shall not be placed until the depth of the excavation and the character of the foundation material have been approved.
- (i) **Backfilling:** Excavated spaces that are not occupied by abutments, piers, or other permanent work shall be backfilled with soil to the surface of the surrounding ground. Backfill shall be uniformly compacted, and the top surface shall be neatly graded.

The fill around the perimeter of abutments, wingwalls, and retaining walls shall be placed in horizontal layers not more than 6 inches in loose thickness and compacted at ± 20 percent of optimum moisture to a density of at least 95 percent as compared to the theoretical maximum density as defined in Division I. Tests for compliance with density requirements will be performed in accordance with the requirements of VTM-12. As the work progresses, backfill in front of units shall be placed and compacted in horizontal layers to the same elevation as the layers behind units until the final elevation in front is reached. Backfill shall be placed in a manner to prevent wedging action against the concrete. Slopes bounding excavation for abutments, wingwalls, or retaining walls shall be destroyed by stepping or serrating. Jetting of the fill behind abutments, wingwalls, or retaining walls will not be permitted.

Fills and backfills around piers not included in the roadway prism shall be constructed in uniformly compacted layers and placed alternately to maintain a uniform elevation on both sides of the structure. However, the density requirement will be waived.

Provision shall be made for drainage of backfill. Two-inch crusher run aggregate, conforming to the requirements of Section 205, shall be placed at the back of weep holes to extend 18 inches behind the entrance to the hole, 18 inches above the elevation of the bottom of the hole, and 18 inches laterally on each side of the centerline of the hole. Where crushed glass is used as porous backfill, No. 78 and/or No. 8 aggregate an 18-inch by 18-inch swatch of drainage fabric meeting the requirements of Section 245.03(c) shall be used to cover the #4 mesh at each weep hole opening exposed directly to crushed glass, or as approved by the Engineer.

Backfill shall not be placed against abutments or wingwalls until concrete has been in place 14 days, exclusive of days on which the average high-low air temperature is below 40 degrees F in the shade or until test cylinders have attained a compressive strength equal to 93 percent of the required 28-day design compressive strength.

Backfill shall be placed as soon as practicable following attainment of the required compressive strength but not later than 30 days after concrete placement. Excavation openings shall be maintained as dry as practicable at the time of backfilling. Backfill shall be placed in a manner to deter impoundment of water and facilitate existing drainage.

- (j) **Filled Spandrel Arches:** Fill for spandrel arches within 1 1/2 times the height of the arch shall be placed in a manner to load the ring uniformly and symmetrically. Fill material shall be homogeneous soil and shall be placed in horizontal layers not more than 6 inches in loose thickness, compacted in accordance with the requirements of Section 303.04(h), and brought up simultaneously from both haunches. Wedge-shaped sections of fill material against spandrels, wings, or abutments will not be permitted.
- (k) **Approach Embankment:** Approach embankment shall be constructed in accordance with the requirements of Section 303.04(h).

401.04—Measurement and Payment

Structure excavation will be measured in cubic yards of material removed from the limits of vertical planes within 18 inches outside the neat lines of footings or of neat work that does not have footings directly beneath it, such as curtain walls or cantilevered wingwalls. It will be measured from the surface of the original ground or approach roadway down to the bottom of the foundation shown on the plans or such foundation as the Engineer may approve, down to 18 inches below the bottom of the neat work not directly over footings, or to the top of existing concrete where excavation is to permit placing new concrete over existing concrete.

When specified on the plans, structure excavation will include material removed outside the limits specified for the substructure, in the vicinity of the substructure on which a superstructure rests, and to a depth of 18 inches below the lowest beam or bottom of the slab of the superstructure or to such depth as shown on the plans. The width of such excavation shall be limited to 18 inches outside the exterior beams or edges of the slab or as shown on the plans.

Excavation above the bottom of a proposed channel change or roadway template or an overpassed road will not be included as structure excavation.

Structure excavation will be paid for at the contract unit price per cubic yard. This price shall include clearing and grubbing, sheeting, shoring, bracing, placing and compacting backfill, dewatering, fur-

nishing and placing aggregate for weep holes, disposing of unsuitable or surplus material, and clearing the channel of obstructions caused by construction operations.

Excavation for drilled-in caissons will be measured in linear feet of drilled hole from the existing ground to the bottom of the finished hole as measured along the centerline of the hole and will be paid for at the contract unit price per linear foot. This price shall include drilling, under reaming, casing, and preparing the hole.

Furnishing and placing backfill will be included in the price for structure excavation and will not be measured for separate payment unless specific material is required by the Engineer and no suitable material is available within the construction limits. When specific material is required for backfill by the Engineer, measurement and payment will be in accordance with the requirements of Section 104.03.

Porous backfill, when a pay item, will be measured in cubic yards of material within the limits shown on the plans or as otherwise directed by the Engineer and will be paid for at the contract unit price per cubic yard.

Pipe underdrains, when a pay item, will be measured in linear feet and will be paid for at the contract unit price per linear foot.

Unsuitable materials removed below the plan foundation will be measured and paid for as structure excavation.

Foundation seals required by the Engineer and that are properly placed for structural adequacy as a part of the planned footing will be accepted as part of the permanent footing. Measurement and payment will be in accordance with the requirements of Section 404.08. Foundation seals that are not required by the Engineer will be included in the price for structure excavation.

Clearing and grubbing within the area defined by lines connecting the extremities of the substructure units, regardless of whether excavation is involved, shall be included in the price for structure excavation unless otherwise specified in the Contract.

Cofferdams will be measured in units of each per foundation and will be paid for at the contract unit price per each. This price shall include furnishing, erecting, maintaining, and removing.

Payment will be made under:

Pay Item	Pay Unit
Structure excavation	Cubic yard
Drilled holes	Linear foot
Porous backfill	Cubic yard
Pipe underdrain (Size)	Linear foot
Cofferdams	Each

SECTION 402—SHEET PILES**402.01—Description**

This work shall consist of furnishing and installing the type of sheet piles shown on the plans or specified by the Engineer to be left in place or removed as part of the finished structure.

402.02—Materials

- (a) **Timber sheet piles** shall conform to the requirements of Section 236 and may be of any species of wood that can be driven satisfactorily. Piles shall be free from worm holes, loose knots, wind shakes, decayed or unsound portions, or other defects that might impair their strength or tightness.
- (b) **Concrete and reinforcing steel for concrete sheet piles** shall conform to the requirements of Sections 217 and 223.
- (c) **Steel sheet piles** shall conform to the requirements of Section 228.

402.03—Procedures

- (a) **Timber Sheet Piles:** Piles shall be sawed with square corners and provided with tongues and grooves of ample proportions, either cut from the solid material or made with three planks securely fastened together. Piles shall be drift sharpened at the lower ends to wedge the adjacent piles tightly together.

The top of piles shall be cut off to a straight line. Piles shall be braced with waling strips that are lapped and joined at splices and corners. Wales shall be in one length between corners and bolted near the top of the piles.

- (b) **Concrete Sheet Piles:** Concrete sheet piles shall be manufactured in accordance with the requirements of Section 403, 404, or 405, as applicable. Installation shall be in accordance with the requirements of Section 403.
- (c) **Steel Sheet Piles:** When assembled in place, pile sections shall be practically watertight at the joints. Painting of steel sheet piles shall be performed in accordance with the requirements of Section 403. Piles shall be provided with tongues and grooves of ample proportions for securely fastening together. Wales and structural supports shall be provided as necessary to ensure structural integrity.
- (d) **Temporary Sheet Piling:** When shown on the plans or directed by the Engineer, temporary sheet piling will be measured in square feet. The horizontal dimensions will be measured continuously along the outer face of the sheet piling. The bottom limit will be the bottom of the excavation shown on the plans or as authorized. The top limit will be the original ground line or, in areas adjacent to traffic, 3 feet above the original ground line, or as otherwise shown on the plans.

402.04—Measurement and Payment

Sheet piles will be measured in square feet of piles remaining in place and will be paid for at the contract unit price per square foot. The horizontal dimensions will be measured continuously along the outer face of the piling. For steel sheet piles, the horizontal dimension used shall be not more than the sum of the laying widths or driving dimensions of the individual piles.

Payment for **temporary sheet piling** will be made at the contract unit price per square foot, which price shall be full compensation for furnishing, driving, and removing the piling.

Sheet piles used for the convenience of the Contractor in his method and means will not be measured for separate payment but will be considered incidental to the work.

Payment will be made under:

Pay Item	Pay Unit
Sheet piles (Type)	Square foot
Temporary sheet piling	Square foot

SECTION 403—BEARING PILES

403.01—Description

This work shall consist of furnishing, driving, cutting off and when required, load-testing piles of the type and dimensions specified on the plans.

403.02—Materials

- (a) **Timber piles** shall conform to the requirements of Section 236.02(b).
- (b) **Steel piles** shall conform to the requirements of Section 228.
- (c) **Steel shells for cast-in-place piles** shall conform to the requirements of Section 228.
- (d) **Concrete** shall conform to the requirements of Section 217. Concrete exposed to tidal water shall contain slag or silica fume.
- (e) **Reinforcing steel**, Grade 40 or 60, for use in precast or cast-in-place piles, shall conform to the requirements of Section 223.

403.03—Pile Types

- (a) **Timber Piles:**

1. **Storing and handling:** Care shall be taken to avoid breaking the surface of treated piles. Cant hooks, dogs, or pike poles shall not be used. Cuts or breaks in the surface of treated piles shall be given three brush coats of the preservative used to treat the pile. Preservative shall be poured into bolt holes.
 2. **Cutoffs:** The tops of piles shall be cut off at the elevation shown on the plans or as directed by the Engineer. Piles that support timber caps or grillage shall be cut off to conform to the plane of the bottom of the superimposed structure. In general, the length of pile above the elevation of the cutoff shall be sufficient to permit removing material damaged by driving. Piles driven to or near the cutoff elevation shall be trimmed or otherwise freed from splintered or damaged material.
- (b) **Precast Concrete Piles:** Precast concrete piles with conventional reinforcement shall be furnished in accordance with the requirements of these specifications. Prestressed concrete piles shall be furnished in accordance with the requirements of Section 405. Piles shall be manufactured to conform to the requirements of Section 404. Class A3 concrete shall be used.

1. **Casting:** Forms shall conform to the requirements of Section 404 and shall be accessible for vibrating, tamping, and consolidating concrete. Care shall be taken to place concrete to produce a satisfactory bond with the reinforcement and avoid segregation of components, honeycomb, or other defects.

Concrete shall be continuously placed in each pile form and consolidated by vibrating. Forms shall be overfilled, the surplus concrete screeded off, and the top surface finished to a uniform, even texture similar to that produced by forms.

2. **Curing:** As soon as piles have set sufficiently, side forms shall be removed and the piles moist cured for at least 7 days. Piles shall not be driven until the concrete has reached the minimum 28-day compressive strength specified in Section 217. Concrete piles for use in brackish or tidal water or alkali soils shall be moist cured for at least 30 days before use.
3. **Finishing:** As soon as forms are removed, piles shall be pointed with mortar that conforms to the requirements of Section 218. Trestle piles exposed to view shall be finished above the ground line with a Class I finish in accordance with the requirements of Section 404.07(a). Foundation piles, that portion of trestle piles that will be below the ground surface, and piles for use in tidal water or alkali soils shall not be finished except by pointing as specified herein. Piles to be used in tidal water shall be protected in accordance with the requirements of Section 404.03(i).
4. **Storing and handling:** Storing, transporting, and handling shall be performed in a manner to prevent bending stresses, cracking, spalling, or other damage. The method of handling shall not induce stresses in the reinforcement of more than 12,000 pounds per square inch or a concrete stress of more than $0.4 f_c$, where f_c is equal to the compressive strength of a control test cylinder at the time of handling. Concrete stress shall be not more than 1,200 pounds per square inch.

Piles shall be supported or picked up only at pickup points shown on the plans or at a greater number of properly spaced pickup points as may be necessary to comply with stress requirements.

5. **Splicing:** Splicing will not be permitted unless deemed necessary by the Engineer. When splicing is permitted, it shall be performed as specified herein. Splicing shall be performed only with the piles in their normal driving position. The final locations of splices shall be below the ground line.

Splices shall be made by providing dowels cast into the upper section of the pile. Dowels shall have a total area of at least 1 1/2 percent of the gross cross-sectional area of the pile and extend at least 30 bar diameters on each side of the splice. At least four dowels shall be used. Dowels shall be bonded into holes drilled or formed into the lower section of the pile. Holes shall be serrated to provide a mechanical bond. At least one dowel hole shall be provided with a bleeder vent near the bottom.

Ends of both sections shall be prepared to ensure that the concrete adjacent to the splice is sound material free from material that would interfere with the action of the bonding agent.

The bonding agent shall be a plasticized cement or other approved compound that can be placed or otherwise forced into the spaces around dowels and between ends of pile sections. The bonding agent shall have a compressive strength equal to that of the concrete and an adhesive strength equal to the shear and tensile strength of the concrete. The agent shall be able to withstand impact and driving stresses and shall have the same resistance as concrete to damaging water and soil conditions. These properties shall be obtained within a time limit consistent with the driving requirements. If compounds require heating, the manufacturer's recommendations shall be followed. The temperature of the concrete and the ambient temperature shall be not less than 50 degrees F at the time the splice is made.

Pile sections shall be held in such a manner that there will be a space of approximately 1/2 inch between the ends to permit free flow of the bonding agent. A splice form extending approximately 18 inches on each side of the splice shall be placed around the ends of the pile sections. The form shall have at least four ports for pouring of the bonding agent and allowing the escape of air. The bonding agent shall be poured simultaneously through two opposing ports. Driving may be resumed after sufficient time has elapsed to permit the bonding agent to develop its required properties.

6. **Build-ups:** When necessary, build-ups shall be made as follows: After driving is completed, the concrete at the end of the pile shall be cut away, leaving the reinforcing steel or strand exposed for a length of 40 diameters. The final cut of the concrete shall be perpendicular to the axis of the pile. Reinforcement similar to that used in the pile shall be securely fastened to the projecting steel, and the necessary forms shall be placed, with care taken to prevent leakage along the pile. The concrete shall be of the same quality as that used in the pile. Just prior to concrete placement, the top of the pile shall be thoroughly wetted and covered with a thin coating of neat cement or other suitable bonding material. Forms shall remain in place at least 7 days and then carefully removed. The exposed surface of the pile shall be finished as specified for precast concrete piles.

(c) **Cast-in-Place Concrete Piles:**

1. **Construction:** Piles shall be cast in previously driven metal shells that shall remain permanently in place. The diameter shown on the plans shall be the nominal diameter of the uppermost section of shell. Shells shall be classified into the following types:
 - a. **For driving without mandrels:** Type A, fluted, uniform taper; Type B, straight pipe.
 - b. **For driving with mandrels:** Type C, corrugated, step taper: when conditions require its use, the lower section may consist of pipe conforming to the requirements for Type B, Type D, corrugated, straight, or uniform taper.

The shell, including the tip, shall be of a design and thickness that are adequate to hold the original shape and prevent distortion of the shell resulting from driving it and any adjacent shell.

The Contractor shall determine whether self-supporting or mandrel-driven shells will be used and the necessary shell thickness.

If the steel shells collapse, the Contractor shall increase the shell thickness or furnish prestressed concrete piles as shown on the plans at his own expense.

Concrete shall be Class A3.

2. **Reinforcement:** Reinforcement shall consist of a cage of No. 6 longitudinal bars tied with a 0.24-inch or greater spiral bar having a 6-inch pitch. If the thickness of the shell wall is less than 0.12 inch, six longitudinal bars shall be used. If the thickness of the shell wall is 0.12 inch or greater, four longitudinal bars shall be used. The depth to which the reinforcement is extended below the top of the shell at the cutoff elevation shall be at least 1/3 the length of the shell, 10 feet below the elevation of material providing firm lateral support, or, in any case, 10 feet, except for shells less than 15 feet in length. The reinforcement shall not extend closer than 5 feet to the tip. If the thickness of the shell is 0.188 inch or more, the length of longitudinal reinforcement required herein may be reduced to 5 feet below the top of the shell provided any splices occurring within the length are made sufficient to develop the full strength of the pile shell. In all cases, the longitudinal reinforcement shall extend 15 inches above the top of the shell and shall be provided with standard hooks.
3. **Inspection of metal shells:** The Contractor shall have available a light suitable for the inspection of each shell throughout its entire length. Improperly driven, broken, or otherwise defective shells shall be removed and replaced. No shell will be accepted whose diameter at any section is altered by more than 25 percent.
4. **Placing concrete:** Concrete shall not be placed until all driving within a radius of 15 feet is completed unless this is not practicable, in which case driving shall be discontinued until the concrete in the last cast pile has been in place at least 7 days.

Concrete shall be placed continuously and consolidated by vibrating. Accumulations of water in shells shall be removed before concrete is placed.

(d) **Steel Piles or Steel Pile Shells:**

1. **Cutoffs:** The use of cutoffs will be permitted as extensions to driven or undriven piles, or as complete piles in themselves, provided the length of each cutoff is equal to or greater than the length of the extension or full-length pile required.
2. **Welding:** Splices, points, or point reinforcement shall be welded in accordance with the requirements of Section 407.04(a) except that welder certification will be required only for the particular welds performed as required for H-pile splices, built-up point reinforcement, and shell splices that require the full strength of the shell to be developed.
3. **Splicing:** For locations requiring pile lengths of 40 feet or less, one splice per pile will be permitted. For lengths over 40 feet up to and including 80 feet, two splices will be permitted. For lengths exceeding 80 feet, one splice per 40 feet will be permitted. Sections less than 10 feet in length shall not be spliced except as a final (top) section of the pile.

Splices on steel H-piles shall be made by means of butt joints with full penetration welds. Piles spliced in a vertical position shall receive a single-bevel groove weld. Piles spliced in a horizontal position shall receive a single vee or V-groove weld. Abutting ends of piles to be spliced shall be properly prepared for welding, including removing damaged material and squaring the two ends. The two sections of pile shall be securely clamped in proper position and alignment prior to welding.

Each splice between abutting pile shell sections shall be welded or adequately connected by mechanical means approved by the Engineer to give a complete seal and shall be of adequate strength to withstand handling, driving, and design stresses. If the diameters of abutting shell sections to be spliced are not the same, the shells shall be telescoped at least 6 inches at splices. When splices are required to develop the full strength of the shell, the top of the outside shell at the splice shall be scalloped to provide sufficient fillet welds. Sections of shell less than 5 feet in length shall not be spliced to another shell except as a build-up after driving is completed. More than one splice shall not be used within any 15-foot length of completed pile.

4. **Protection by painting:** When steel piles or steel pile shells extend above the ground or water surface, they shall be protected by one coat of No. 14 primer and one coat of epoxy mastic as specified in Sections 231.03(b) and 231.03(c). The coating thickness shall be as specified in Section 411, Table IV-6. Protection shall extend from an elevation 2 feet below the lowest ground or water surface up to a level 2 inches into the concrete in which their tops are to be embedded.
5. **Variations in length:** Where steel H-piles are driven in limestone areas or where extreme variations in length are likely to be encountered, the following procedure shall be used: Wherever a pile has been driven to a depth requiring a length exceeding by 30 percent or 15 feet, whichever is greater, the length determined in accordance with the requirements of Section 403.04 or as indicated by the borings or piles already driven, the pile shall not be driven further until all other piles in the pier, abutment, or retaining wall have been driven or until a sufficient number has been driven to indicate clearly the trend of lengths. The Engineer will then determine the method to be used.

403.04—Determination of Pile Lengths

For cast-in-place piles, the Contractor shall determine the type, thickness, and driving criteria of the steel pile shell. Lengths shall be determined by performing driving tests.

A driving test shall be performed by driving a pile of the same type and size as that required or proposed for the specific structure at each location shown on the plans or otherwise approved by the Engineer.

Driving test piles that are not to be load tested or dynamically analyzed shall be driven their full length or until practical or absolute refusal is reached.

403.05—Order List

The Contractor shall submit to the Engineer for approval an itemized list for precast concrete and timber piles prior to placing the order with the supplier. The list shall include the lengths required for each pile location and the corresponding full or partial lengths of piles to be ordered.

Driving tests, dynamic pile tests, loading tests, and refined wave equation analyses shall be completed for a substructure element prior to submission of an order list for the substructure element.

403.06—Procedures

- (a) **Suitability of Foundation:** If there is any indication that piles cannot be driven in accordance with the requirements of these specifications or if the foundation material appears to be capable of supporting footings without piles, the foundation shall be explored in accordance with the requirements of Section 401.03(b) and the results of the exploration submitted to the Engineer for review to determine whether piles will be omitted and the substructure adjusted to give adequate bearing on a firm foundation.
- (b) **Preparation for Driving:** Piles shall not be driven until excavation is complete. Material forced up between piles shall be removed to correct the foundation elevation before concrete for the foundation is placed.

Piles for supporting abutments on very soft or swampy original ground or on newly placed fill shall not be driven until the approach embankment, including any fill in front of the abutment, has been completed to the elevation of the top of the earthwork and compacted as specified in Section 303.

Piles shall not be driven in proximity to uncured concrete.

- (c) **Protection During Driving:** Heads of concrete piles shall be protected by caps of an approved design, with a suitable cushion equivalent to at least 4 inches of plywood or a sufficient amount as site-specific conditions dictate, next to the pile head and fitting into a casing that supports a shock block. During driving, the cap block and cushion shall be changed if compressed more than 50 percent or as required to prevent damage to the pile. When the area of the head of any timber pile is greater than that of the face of the hammer, a suitable cap shall be provided to distribute the blow of the hammer throughout the cross-section of the pile.

For special types of piles, driving heads, mandrels, or other devices shall be used in accordance with the manufacturer's recommendations so that the pile may be driven without damage.

For steel piles, heads shall be cut squarely and a driving cap provided to hold the axis of the pile in line with the axis of the hammer.

Timber piles that are not enclosed in concrete shall be protected as specified in Section 418.03(d). Collars, bands, or other devices to protect timber piles against splitting and brooming shall be provided when specified by the Engineer.

Tips for timber piles shall be sharpened. When specified, timber piles shall be provided with steel or cast iron points conforming to the requirements of Section 236.02(b). When points are used, the tips of the piles shall be carefully shaped to secure an even and uniform bearing on the points.

When specified, steel H-piles shall be provided with cast steel points. Points shall be welded as recommended by the manufacturer, but the length of the weld shall be not less than twice the width of the flange.

If during the driving of a precast concrete pile a reduction in blow count indicates that the point of the pile has passed from a harder material into a softer material that offers little or no resistance to penetration, the energy per blow shall be reduced to an amount specified by the Engineer. When firm-bearing material is reached, the energy per blow shall be returned to normal.

Steel piles and steel pile shells shall be painted as specified in Section 403.03(d)4.

- (d) **Driving:** The capability of the hammer to drive piles properly will be verified from records of the test piles. If the required penetration is not obtained in the driving test by the use of a hammer complying with the requirements, the Contractor shall provide a heavier hammer or use other approved means at his own expense. The method of driving shall not produce deformed piles. Where determined necessary by the Engineer in order to obtain the required tip elevation, design bearing capacity, or minimum penetration, driving shall be supplemented by jetting or preboring. After driving is completed, voids existing as a result of preboring, soil consolidation, or movement shall be filled with dry sand and consolidated to provide adequate lateral pile support. Damaged piles shall be removed and replaced.

1. **Hammers for timber and steel H-piles:** Hammers may be either gravity or power hammers. Striking parts of gravity hammers for driving timber piles shall weigh at least 2,000 pounds and for driving steel piles at least 3,000 pounds. In no case shall the weight of the striking parts of gravity hammers be less than the combined weight of the pile and any device used on the pile head for protection during driving. The hammer fall shall be regulated to avoid damage to piles. The fall shall be not more than 15 feet.

Power hammers shall be capable of developing at least 7,000 foot-pounds of energy per blow when driving timber piles and at least 15,000 foot-pounds of energy per blow when driving steel piles.

2. **Hammers for concrete piles:** Precast concrete piles or shells for cast-in-place piles shall be driven with a power hammer that shall develop an energy per blow of at least

0.2 foot-pound per pound of the design bearing capacity of the pile being driven. Power hammers shall develop an energy (E) in foot-pounds per blow of at least 1 foot-pound per pound of pile weight (W) for piles weighing up to 25,000 pounds. For piles weighing more than 25,000 pounds, E shall be at least $25,000 + 0.6 (W - 25,000)$. The value of E shall be at least 15,000 foot-pounds per blow.

3. **Leads:** Pile driver leads shall be constructed in a manner that will afford freedom of movement of the hammer and shall be held in position by guys or stiff braces to ensure support of the pile during driving. Except where piles are driven through water, leads shall be of sufficient length so that a follower will not be necessary.

Inclined leads shall be used in driving battered piles.

4. **Followers:** Followers shall be used only with the written permission of the Engineer. When followers are used, 1 pile from every group of 10 shall be a long pile driven without a follower and shall be used as a test pile to determine the average bearing capacity of the group.
 5. **Water jets:** The volume and pressure of water at the jet nozzles shall be sufficient to erode freely the material adjacent to the pile. A pressure of at least 100 pounds per square inch shall be delivered at the nozzles. At least two jet nozzles having a diameter of at least 3/4 inch shall be used and placed symmetrically about the circumference of the pile. Before the desired penetration is reached, the jets shall be withdrawn and the piles driven at least 5 feet or to the depth determined by the Engineer to be necessary to secure the final penetration.
 6. **Preboring:** The area of each prebored hole shall be approximately 10 percent more than the area of the pile but not more than 20 percent of the area.
- (e) **Penetration:** In general, the penetration for any pile shall be at least 10 feet. In soft material, the penetration shall be at least 20 feet. Where piles are driven through fills, they shall penetrate at least 5 feet into undisturbed original ground under the fill. Friction piles, other than steel H-piles, in fills shall be driven through prebored holes extending to the elevation of the original ground.
- (f) **Accuracy of Driving:** Piles shall be driven to within the tolerances specified in Table IV-1 for positions at cutoff elevations.

Piles shall not be driven with a variation of more than 1/4 inch per foot from the vertical or batter specified.

Steel and concrete piles shall not be subjected to force in order to place them in correct alignment or a horizontal position. The position of a timber pile that lies within the tolerance allowed for the driven position as specified in Table IV-1 under pile type No. 4, Condition (a) or (b), shall be corrected to the tolerance given for pile type No. 5, Condition (a) or (b), respectively, by the application of horizontal force wherever conditions will permit such corrective work without damage to the pile.

If the distances between the actual and theoretical pile centers or centers of gravity are more than the specified tolerances, the piles will be considered unacceptable unless the Contract

tor submits a satisfactory working plan showing the corrective work proposed. Such work shall not proceed until the plan has been approved by the Engineer.

The clear distance between the heads of piles and edges of footings shall be at least 6 inches. Additional concrete and reinforcement required to maintain the required minimum clear distance shall be placed only with the prior approval of the Engineer and shall be furnished at the Contractor's expense.

Timber piles driven below the cutoff elevation specified on the plans or by the Engineer or otherwise driven outside the limits for the driven position specified herein shall be withdrawn, and a replacement pile driven in the correct position at the Contractor's expense. Other types of piles driven to below the required elevation may be spliced or built up as otherwise provided for in these specifications.

(g) **Bearing Capacities:** Piles shall be driven to the following capacity:

1. **Steel H-piles** shall be point bearing and shall be driven to practical or absolute refusal. Steel H-piles designated as friction piles shall be driven to a safe bearing capacity of at least 3 tons per inch of nominal size.
2. **Timber piles** shall be driven to a safe bearing capacity of at least 20 tons per pile.
3. **Precast concrete piles and shells for cast-in-place concrete piles** shall be driven to a safe bearing capacity of at least 3 1/2 tons per inch of the nominal diameter or side dimension.

TABLE IV-1
Pile Tolerance Criteria

Pile Type	Condition	Tolerance for Position of		
		Single Group (in)	Direction	Center of Gravity for Pile Group ¹ Tolerance
1. Steel and Concrete	Column supports for bent caps	±3	About long axis of footing	3% of distance between extremes ² or 1 1/2 in, whichever is greater
2. Steel and Concrete	(a) Footing supports for box culverts	±6	About both major axes	3% of distance between extremes ² or 1 1/2 in, whichever is greater
	(b) Footing supports for column piers	±6		
3. Timber	(c) Footing supports for abutments, retaining walls, and piers other than column piers	±6	About long axis of footing	3% of distance between extremes ² or 1 1/2 in, whichever is greater
	Footing supports for box culverts	±9	About both major axes	3% of distance between extremes ² or 1 1/2 in, whichever is greater
4. Timber	(a) Footing supports for column driven through material that will permit correction of position without damage to pile	±9	About long axis of footing	4 1/2% of distance between extremes ² or 2 1/4 in, whichever is greater
	(b) Footing supports for abutments, retaining walls, and piers other than column piers driven through material that will permit correction of position without damage to pile	±9		
5. Timber	(a) Footing supports for column piers driven through material that will not permit correction of position	±6	About both major axes	4 1/2% of distance between extremes ² or 2 1/4 in, whichever is greater
	(b) Footing supports for abutments, retaining walls, and piers other than column piers driven through material that will not permit correction of position	±6	About long axis of footing	4 1/2% of distance between extremes ² or 2 1/4 in, whichever is greater
6. Timber	Fender systems and other uses requiring non-load As required for proper attachment of wales, bracing, etc., or tying of groups for dolphins bearing piles			

¹Piles under a separate footing of individually constructed units shall be considered a separate group. The tolerances expressed as a percentage of "distance between extremes" will be allowed only about the axis for which it is computed.

²If the group consists of a single row of piles, the distance shall be measured from the centerline of the row to the centerline of the footing.

- (h) **Disposing of Pile Cutoffs:** Upon completion of pile driving operations for structures on the project, pile cutoffs left in storage, including precast concrete and timber cutoffs, shall become the property of the Contractor and shall be disposed of off the project.

403.07—Determination of Bearing Capacities

- (a) **Loading Tests:** When required, the safe bearing capacities of piles shall be determined in accordance with 72-hour or quick load tests as specified herein.

The loading test shall commence no sooner than 5 days after the pile to be tested has been driven. Telltales consisting of steel rods 1/2 inch in diameter shall be lubricated and inserted in plastic pipe 3/4 inch in inside diameter. Individual sections of telltales shall be joint coupled flush so that each rod is of uniform diameter throughout its length.

Where necessary, the unsupported length of the test pile shall be braced to prevent buckling without influencing the test results.

The clear distance from the reaction frame to the test pile shall be at least 5 times the maximum diameter of the test pile or as approved by the Engineer.

Loading shall be applied through a hydraulic jack with spherical bearings jacked against a platform load. The loading apparatus shall have a capacity of at least that required for the test. If more than one jack is used, the jacks shall have the same piston diameter, be connected to a common manifold and pressure gage, and be operated by a single hydraulic pump.

The method of determining test loads shall be by using a pressure gage or load cell. The pressure gage, hydraulic ram, and hydraulic pump shall be calibrated as a unit to an accuracy of at least 5 percent of the applied load. If a multiple jacking system is used, each jack shall be fitted with a pressure gage in addition to the master gage. Load-measuring devices shall have been calibrated not more than 3 months prior to the loading test and shall be recalibrated when directed by the Engineer.

Loads shall be applied uniformly with no impact. The load cell or pressure gage shall be continuously monitored, and the jacking pressure adjusted to maintain a constant load.

The load shall be applied to a steel test plate of appropriate thickness for the loads involved and of a size not less than the size of the pile butt and not less than the area covered by the base(s) of the hydraulic jack rams. The plate shall be set in high-strength, quick-setting grout to ensure a uniform bearing. Provision shall be made for the telltale rod to extend through the test plate.

Movement of the pile butt and telltale relative to the pile butt shall be measured with dial gages to an accuracy of 0.001 inch. Dial gages shall have a travel of at least 2 inches, and gage blocks shall be provided to record measurements as required. The pile butt shall be measured by dial gages attached to an independently supported frame. Movement shall be measured by a secondary system consisting of a scale, mirror, and piano wire. The scale and mirror shall be attached parallel with the longitudinal axis of the pile. The wire shall be properly tensioned and supported so that it passes within 1 inch of the face of the scale. The scale shall have gradations of 1/100 of an inch.

Supports for dial gage frames and wires shall be more than 7 feet clear of the pile and as far from anchor piles or reaction supports as is practicable. Supports and frames shall be checked by a surveyor's level.

Gages and measuring devices shall be protected from the weather, including direct sunlight. Adequate ventilation shall be provided to prevent fogging or frosting of the gages.

The Contractor shall provide the Engineer reasonable access to and from the site of the test pile. The Contractor shall assist the Engineer in recording load, settlement, and rebound measurements throughout the test and shall furnish complete information on the driving equipment used and the pile driving record.

Other piles of the same type and size that are not load tested shall be driven to the safe bearing capacity of at least that required for the satisfactory load-tested pile(s).

1. **The 72-hour loading test** shall be 200 percent of the design capacity applied in increments of 25 percent of the design capacity. Each load increment shall be maintained until the rate of settlement is not greater than 0.01 inch per hour or until 2 hours have elapsed, whichever occurs first. The test load shall be applied fully and continuously for at least 72 hours and shall produce no measurable settlement during the last 24 hours. After the required holding time, the test load shall be removed in decrements of 25 percent of the total test load with at least 1 hour between decrements.

Permanent settlement of the pile after completion of the specified loading test shall be not more than 1/4 inch. If the permanent settlement is more than 1/4 inch, the Contractor shall redrive and test load the same pile or drive and test load additional piles until the loading test is satisfactory.

Proven safe bearing capacity for piling from the 72-hour loading test is defined as 1/2 the test load for a satisfactory loading test.

2. **The quick load test** shall be 300 percent of the design capacity applied in increments of 10 percent of the design capacity with a constant time interval between increments of 5 minutes. Load increments shall be added until continuous jacking is required to maintain the test load or until the specified capacity of the loading apparatus is reached, whichever occurs first. After a 10-minute interval, the full test load shall be removed in four approximately equal decrements with 5 minutes between decrements.

The Contractor shall record readings of time, load, and settlement for the pile and tell-tale immediately before and after applying each load increment. When the maximum load has been applied, the Contractor shall record when jacking is stopped. Readings shall be repeated after 5 minutes and again at 10 minutes after jacking has stopped. Readings of time, load, and rebound shall also be recorded after each decrement during load removal and repeated 5 minutes and 10 minutes after the load has been removed.

The ultimate bearing capacity of a pile tested under an axial compressive load is that load which produces a settlement of the pile head equal to the following:

$$S_f = S + (0.15 + 0.008D)$$

Where:

S_f = settlement at failure in inches;

D = pile diameter or width in inches;

S = elastic deformation of pile length in inches = $P_i L / AE$;

P_i = load on pile in pounds;

L = length of pile in inches;

A = area of pile in square inches; and

E = the modulus of elasticity of the pile [57,000 f.c. for concrete; 29(10⁶) for steel].

Proven safe bearing capacity for piling is defined as 1/2 the ultimate bearing capacity obtained and shall be at least the required design capacity. If the proven safe bearing capacity is less than the required design capacity, the Contractor shall redrive and test load the same pile or drive and test load additional piles until the loading test is satisfactory.

- (b) **Timber Piles:** If timber piles are not required to be driven to practical refusal or if their safe bearing capacity is not required to be determined by loading tests, their theoretical safe bearing capacity shall be determined by the following formulas:

$$P = \frac{2WH}{S + 0.1} \quad \text{for single-acting steam hammers}$$

$$P = \frac{2H(W + Ap)}{S + 0.1} \quad \text{for double-acting steam hammers}$$

$$P = \frac{2WH}{S + 0.1} \quad \text{for gravity hammers}$$

$$P = \frac{1.6E}{S + 0.1} \quad \text{for diesel hammers}$$

Where:

P = theoretical safe bearing capacity in pounds;

W = weight in pounds of striking part of hammer;

H = height of fall in feet;

S = average penetration in inches per blow for the last 5 to 10 blows for gravity hammers and the last 10 to 20 blows for power hammers;

A = area of piston in square inches;

p = steam pressure in pounds per square inch at the hammer; and

E = equivalent energy in foot-pounds as determined by a gage attached to the hammer for hammers with enclosed rams or the weight in pounds of the ram multiplied by the length of travel in feet for hammers without enclosed rams. The value of E shall be not more than the manufacturer's rating for developed energy.

These formulas are applicable only when (1) the hammer has a free fall, (2) the head of the pile is not broomed or crushed, (3) the penetration is reasonably quick and uniform, or (4) a follower is not used.

If there is an appreciable bounce, twice the height of the bounce shall be deducted from H to determine its value in the formula.

If the Engineer determines that energy losses attributable to pile rebound exceed the nominal values assumed in these formulas, safe bearing capacity shall be reevaluated by wave equation analysis or substantiated pile formulas that rationally consider energy losses in the cap, pile, and soil.

When water jets are used in connection with driving, the capacity shall be determined by the formulas from the results of driving after the jets have been withdrawn or by application of a test load.

Theoretical safe bearing capacity for piling from the timber pile formulas shall be no less than the required design capacity.

- (c) **Bearing Value of Piles:** Bearing values for concrete and steel piles shall be determined by the loading tests specified in (a) herein. In the absence of loading tests, safe-bearing capacities may be determined using a dynamic pile analyzer during pile driving or results of wave equation analysis. In the absence of loading tests, wave equation analysis, or a dynamic pile analyzer, the safe bearing capacity may be approximated by using substantiated pile formulas or the timber pile formulas given in (b) herein. The character of the soil penetrated; conditions of driving; followers; size, length, and weight of the piles; and computed load per pile shall be given due consideration in determining the safe bearing capacity.

Bearing piles shall be driven until the blow count determined to produce the required design capacity has been continuously maintained for 3 feet or to practical or absolute refusal, whichever occurs first. *Practical refusal* is defined as twice the blow count required to produce a safe bearing capacity when maintained for 1 foot. *Absolute refusal* is defined as 4 times the blow count required to produce a safe bearing capacity when maintained for 1 inch.

A pile shall not be driven above the blow count if wave equation analysis indicates that maximum stress levels will be exceeded.

The following are the maximum allowable driving stresses (attributable to hammer impact only):

1. **Prestressed concrete piles:**
 - a. **Compression:** $0.85 f_c$ – unit prestress (after losses)
 - b. **Tension :** $3/f_c$ + unit prestress (after losses)
2. **Steel piles:**
 - a. **Compression:** $0.9 F_y$
 - b. **Tension:** $0.9 F_y$

At the Contractor's option, piles reaching bearing value with heads above the cutoff grade may be driven to the cutoff grade provided driving is less than practical refusal and no damage to the pile occurs.

When required by the Engineer, a pile shall be restruck with the same hammer and cushion system used for the initial driving. Pile restrike shall be at least 24 hours after initial driving. A cold hammer shall not be used for the restrike. The hammer shall be warmed up prior to restrike by striking at least 20 blows on a pile that is at least 25 feet from the pile to be restruck. The maximum amount of penetration required during restrike shall be 6 inches or the maximum total number of hammer blows required shall be 50, whichever occurs first.

403.08—Measurement and Payment

Piles will be measured in linear feet from the tip (excluding any added pile point) to the head of the pile remaining in place in the completed structure and will be paid for at the contract unit price per linear foot. This price shall include furnishing piles; driving piles; splices; obtaining safe bearing capacity, tip elevation, or minimum penetration; jetting; performing wave equation analysis; disposing of piling cutoffs; concrete and reinforcing steel required for steel shell piles, including reinforcing steel that extends into the structure footing; painting; and waterproofing.

Precast concrete and timber cutoffs will be measured in linear feet of pile excluding that portion of the precast concrete pile the Contractor elects to furnish to facilitate driving. Only precast concrete and timber cutoffs will be paid for. Payment will be limited to the invoice price plus 15 percent, not to exceed the contract unit price per linear foot of pile.

Pile points for timber and steel H-piles will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each. This price shall include furnishing and attaching to the pile.

Driving tests shown on the plans or required by the Engineer will be measured in linear feet and will be paid for at the contract unit price per linear foot. Piles used in driving tests will be measured from the tip (excluding any added pile point) to the head of the pile. When a pile used in a driving test is incorporated in the completed structure at the required location, no separate measurement of the pile will be made for payment. This price shall include performing the test; furnishing, removing, and disposing of piles; and restoring the pile hole when the pile is not incorporated in the structure.

Driving tests not specified on the plans or required by the Engineer but performed to determine lengths or other required properties will not be measured as driving tests. However, when piles used for the tests are incorporated in the completed structure, they will be measured and paid for the same as other piles of the same type.

Loading tests will be measured in units of each and will be paid for at the contract unit price per each. This price shall include performing the loading test. If a loading test is terminated by the Engineer because of insufficient bearing capacity, the test will be measured for payment. If a loading test is terminated because of malfunction of the Contractor's equipment or other reasons that are the fault of the Contractor, the test will not be measured for payment.

The length of pile driven to the cutoff grade after obtaining required bearing will be measured in linear feet and will be paid for as cutoff.

Preboring fills in accordance with the requirements of Section 403.06(e) will not be measured for separate payment. The cost thereof shall be included in the price for pile.

Pile restrike will be measured in linear feet of pile from the tip, excluding any added pile point, to the head of the pile remaining in the structure. Payment will be made at the contract unit price for the driving test for the same size and type pile less the invoice price per foot for the pile. This price shall include the equipment and driving effort required for the restrike.

Jetting not shown on the plans and specified by the Engineer in accordance with the requirements of Section 403.06(d) will be measured in linear feet and will be paid for per linear foot at 30 percent of the contract unit price per linear foot for the particular size and type of pile for which the jetting was ordered. This price shall include disposing of surplus material and erosion, siltation, and water quality controls required as a result of the jetting operations.

Preboring not shown on the plans and specified by the Engineer in accordance with the requirements of Section 403.06(d) will be measured in linear feet for the particular size and type of pile for which the preboring was ordered in accordance with the requirements of Section 104.03 and Section 109.05. This price shall include disposing of surplus material and erosion and siltation controls when required as a result of the preboring operations.

Preboring shown on the plans will be measured in linear feet for the particular size and type of pile for which preboring was specified. This price shall include disposing of surplus material erosion and siltation controls when required as a result of the preboring operations.

Payment will be made under:

Pay Item	Pay Unit
Pile (Type and size)	Linear foot
Pile point for (Size and type) pile	Each
Driving test for (Size and type) pile	Linear foot
Loading test for (Size and type) pile	Each
Preboring (Size and type) pile	Linear foot

SECTION 404—HYDRAULIC CEMENT CONCRETE OPERATIONS

404.01—Description

This work shall consist of furnishing and placing hydraulic cement concrete in accordance with these specifications and in conformity with the dimensions, lines, and grades shown on the plans or as established by the Engineer.

404.02—Materials

- (a) **Concrete** shall conform to the requirements of Section 217. Aggregate used in concrete for bridge decks shall be nonpolishing.

- (b) **Curing materials** shall conform to the requirements of Section 220.
- (c) **Concrete admixtures** shall be used as specified in Section 215 and Section 217.
- (d) **Corrugated metal bridge deck forms** shall be galvanized steel conforming to the requirements of ASTM A653, Grade SS40, SS50, or SS80, and shall be coating designation G165. Supports, closures, and other fabricated parts shall conform to the requirements of ASTM A653, Grade SS33, SS40, SS50, or SS80, and shall be coating designation G165.
- (e) **Prestressed concrete deck panels** shall conform to the requirements of Section 405 except as specified herein.
- (f) **Anchor bolts** shall conform to the requirements of Section 226.
- (g) **Reinforcing steel** shall conform to the requirements of Section 223.
- (h) **Waterstops** shall conform to the requirements of Section 212.

404.03—Procedures

- (a) **Forms:** On concrete beam bridges, the Contractor shall have the option of using corrugated metal bridge deck forms, prestressed deck panels, or wood forms to form that portion of bridge decks between beams unless otherwise specified on the plans. On steel beam bridges, the Contractor shall have the option of using corrugated metal bridge deck forms or wood forms to form that portion of bridge decks between beams or girders unless otherwise specified on the plans. However, corrugated metal forms and prestressed deck panels shall not be used to form overhangs or portions of slabs where a longitudinal joint occurs between beams or girders.

Devices for supporting forms of any type shall not be welded to steel beams or girders unless specified on the plans.

Formwork shall be mortartight and of sufficient rigidity to prevent distortion attributable to the pressure of the concrete and other loads incidental to construction operations.

Forms for exposed surfaces shall have a form liner of an approved type and shall be mortartight. Forms for exposed surfaces below the bottom of slabs of bridges, including substructures, and on endwalls and wingwalls of culverts down to an elevation of 1 foot below low water or 2 feet below the final ground line above water shall be faced with metal, plyboard, or other approved smooth-faced material constructed to provide a minimum of joints and prevent leakage. Concrete shall present a uniform and smooth surface without requiring touch-up or surface finishing upon removal of forms. Uneven joint protrusions of more than 1/8 inch shall be removed. Forms shall be filleted 3/4 inch at sharp corners and given a bevel or draft in the case of projections, such as girders and copings, to ensure easy removal.

Metal ties or anchorages within the form shall be constructed to permit their removal to a depth of at least 1 inch from the face without damage to the concrete. If ordinary wire ties are permitted, wires shall be cut back at least 1/4 inch from the face of the concrete with chisels or nippers upon removal of forms. Fittings for metal ties shall be of such design that

cavities left upon their removal will be the smallest size possible. Cavities shall be filled with cement mortar, and the surface left sound, smooth, even, and uniform in color.

Forms shall be set and maintained true to line. When forms appear to be unsatisfactory, either before or during concrete placement, the Engineer may order the work stopped until defects have been corrected.

The shape, strength, rigidity, watertightness, and surface smoothness of reused forms shall be maintained at all times. Warped or bulged lumber shall be resized before being reused.

For narrow walls and columns where the bottom of the form is inaccessible, the lower form boards shall be left loose so that they may be removed for cleaning immediately before concrete placement.

Forms shall be treated with an approved oil or form-coating material or thoroughly wetted with water immediately before concrete placement. For rail or other units with exposed faces, forms shall be treated with an approved oil or form-coating material to prevent adherence of concrete. Material that will adhere to or discolor concrete shall not be used.

Forms shall be maintained at a temperature that will not adversely affect curing of concrete.

Formed voids in concrete shall be of accurate dimensions and locations so that the thickness of surrounding concrete shall not be reduced from plan dimensions.

Methods of positioning void forms and placing surrounding concrete shall be subject to the approval of the Engineer prior to their use.

Bridge deck slabs shall be constructed in a manner so that the thickness of the finished slab shall be not less than the thickness shown on the plans or more than the thickness plus 1/2 inch.

1. **Corrugated metal bridge deck forms:** If the Contractor elects to use corrugated metal bridge deck forms, he shall submit details of the forms, including fabrication and erection details, to the Engineer for approval in accordance with the requirements of Section 105.10. Forms shall be designed and erected in accordance with the following:
 - a. **Design:** The thickness of forms shall be at least 20 gage (0.037 inch). The unit working stress in the sheet metal and supporting units shall be not more than 0.725 of the specified minimum yield strength of the material furnished. In no case shall it be more than 36,000 pounds per square inch. The maximum stress under a design load equal to the weight of the forms and plastic concrete plus a construction live load of 50 pounds per square foot shall be not more than the unit working stress for the material furnished. Deflection of forms under the weight of the form, plastic concrete, and reinforcement shall be not more than 1/180 of the span of the forms or 1/2 inch, whichever is less. In no case shall the loading be less than 120 pounds per square foot total.

When the actual dead load attributable to the use of metal bridge deck forms is more than the design allowance for construction tolerances and methods shown on the plans, the Contractor shall strengthen the beams or girders to the extent

necessary to maintain the design live load rating of the bridge and shall submit supporting information and calculations to the Engineer for review.

- b. **Erection:** Forms shall be installed in accordance with reviewed fabrication and erection plans. Field cutting of forms, supports, and closures at expansion joints, diaphragms, and abutments in skewed areas or in any area where girders or beams are not parallel shall be performed with saws or shears. The outstanding leg of the support angle, channel, or other device shall be not more than 3 inches.

Form sheets shall not rest directly on the top of the stringer or floor beam flanges. Sheets shall be securely fastened to form supports and shall have a minimum bearing length of one inch at each end. Form supports shall be placed in direct contact with the stringer or floor beam flange by hangers or clips. Attachment of the forms to the form supports shall be made by permissible welds, screws, clips or other approved means. Fasteners along the ends and edges of form sheets shall be spaced at intervals not to exceed 18 inches.

Welding and welds shall conform to the requirements of Section 407.04 except that 1/8-inch fillet welds will be permitted.

Permanently exposed form metal whose galvanized coating has been damaged shall be repaired in accordance with the requirements of Section 233.

Corrugated metal forms shall be positioned such that the specified cover for the reinforcing steel and minimum design slab thickness are maintained above crests of the corrugation.

Transverse construction joints shall be located at the bottom of a flute, and 1/4-inch weep holes shall be field drilled at not more than 12 inches on center along the line of the joint.

Closures at edges of forms parallel to beams or girders shall be made by crimping corrugations. Closures at skewed ends may be of the serrated or channel type.

The design span of the sheet shall be the clear span of the form plus 2 inches measured parallel to form flutes.

The permissible form camber shall be based on the actual dead load condition. Camber shall not be used to compensate for deflection in excess of the foregoing limits.

Physical design properties shall be computed in accordance with the requirements of AISI's specifications for the design of cold-formed steel structural units.

- c. **Inspection:** After concrete has been in place for at least 2 days, the Contractor shall sound at least 50 percent of the area of at least 25 percent of the individual form panels using a moderate blow administered with a carpenter's hammer. Individual form panels to be sounded will be selected randomly by the Engineer. Areas of questionable soundness shall be exposed by removing forms. The amount of sounding and form removal required will be adjusted as the work progresses according to conditions detected by the investigation. When procedures, materi-

als, or equipment used during placement of concrete warrant additional inspection of the underside as determined by the Engineer, the Contractor shall remove at least one form panel at each location selected by the Engineer. If the initial inspection reveals inferior workmanship or unsatisfactory material as determined by the Engineer, additional panels shall be removed to ascertain the extent of the deficiency. The Contractor will not be required to replace metal forms at locations where sections of forms are removed for inspection purposes. However, adjacent metal forms and supports shall be repaired to the extent necessary to render their attachment secure.

The Contractor shall provide facilities required for the safe and convenient conduct of the Engineer's inspection.

2. **Prestressed deck panel forms:** If the Contractor elects to use prestressed deck panel forms, he shall redesign the deck slab in accordance with the requirements of AASHTO's *Standard Specifications for Highway Bridges* and the interim specifications as modified by the Department and shall submit the redesign of the deck slab, reinforcing steel schedule, design calculations, and working drawings to the Engineer for acceptance in accordance with the requirements of Section 105.10. Working drawings shall show the permissible construction live load. The Contractor's submittal shall be made at least 60 days prior to the time necessary for ordering materials for the work.
 - a. **Design:** The following conditions shall apply to the redesign of the cast-in-place deck slab:
 - (1) The size, spacing, and area of transverse reinforcing steel in the top of deck slabs shall be not less than that shown on the plans. The transverse reinforcing steel shown on the plans in the bottom of the deck slab shall be eliminated.
 - (2) Longitudinal reinforcing steel shown on the plans in the bottom of the deck slab shall be replaced by reinforcing bars having the identical size and spacing as the main transverse reinforcing bars in the deck slab. These bars shall be placed 1/2 inch clear above the top of the deck panels. Longitudinal reinforcing steel shown on the plans in the top of the deck slab may be eliminated, except over intermediate supports of continuous spans, provided adequate tie bars having no more than 24-inch spacing are used for securing top transverse steel. The distance from the face of the concrete to the center of the top layer of main reinforcing steel shall be 2 3/4 inches.
 - (3) Shear connectors on steel beams or girders and vertical reinforcement in prestressed concrete beams may be adjusted to facilitate placing prestressed deck panels.
 - (4) The design for deck panels shall provide for the same total slab thickness as shown on the plans.
 - (5) When epoxy-coated steel is specified on the plans, reinforcing steel in the cast-in-place section of the slab shall be epoxy coated.

- (6) The depth of intermediate diaphragms for prestressed concrete beams shall be modified to provide clearance between the panel and diaphragm.
- (7) Lifting devices installed in panels for handling may be left in place provided they do not project closer than 2 inches to the finished deck surface.
- (8) Panels will not be allowed over the end supports for bridges skewed more than 15 degrees. End sections of slabs shall be cast the full depth shown on the plans.
- (9) Panels shall be roughened in the direction parallel to the strands.

The following conditions shall apply to the design of the deck panels:

- (1) The strand size shall be not more than 3/8 inch.
- (2) A cover of at least 1 1/2 inches shall be provided on the bottom of deck panels for prestressing strands and reinforcing steel.
- (3) The cracking load a unit can sustain shall be at least $1.2(D) + 1.5(L+I)$ without the concrete tensile stress exceeding $7.5 f_c$

Where:

D = dead load;

$L+I$ = live load + impact; and

f_c = the 28-day design compressive strength of concrete in pounds per square inch.

- (4) At least 0.11 square inch per foot of reinforcing steel transverse to strands shall be provided in panels.
- (5) The length of the panel in the direction of strands shall be at least 5 feet 2 inches.
- (6) Strands shall project at least 3 inches from the concrete at both ends of the panel.
- (7) Mild reinforcing steel in the deck panel, including tie bars and reinforcing bars used for panel-lifting purposes, shall be epoxy coated. Bar supports shall conform to the requirements of Section 406.03(d).

Panel sides that are parallel to the strands may be cast to provide full-depth contact with the adjacent panel or cast with angular sides that, when installed with an adjacent panel, will form a V-shaped joint, which shall be mortar-tight at its base.

- b. **Erection:** Precast bridge deck panels shall be erected in accordance with the accepted working drawings and with the strands transverse to the longitudinal direction of the beams. Panels shall be tightly butted together and shall be mortar-tight,

with panel joints staggered on each side of the supporting beam. Panel joints that are not in full contact or that are not mortartight shall be sealed by epoxy mortar or other approved method at the Contractor's expense.

Prior to placement of the deck surface concrete, foreign material detrimental to achieving a bond shall be removed by sandblasting, waterblasting, or other approved methods. The top surface of deck panels shall be thoroughly and continuously water soaked for at least 1 hour prior to placement of deck surface concrete. Puddles of standing water shall be removed prior to placement of deck surface concrete. Panels shall be supported by one of the following methods to provide the same total slab thickness as shown on the plans:

- (1) Nonshrink cement mortar bed $3 \pm 1/4$ inches in width with a thickness of at least $1/2$ inch conforming to the requirements of Section 218 except that the compressive strength shall be 5,000 pounds per square inch. When shims are used to construct the mortar bed, they shall be removed prior to placement of the deck concrete.
- (2) Galvanized steel support angles having an outstanding leg width of at least 1 inch and a thickness of at least $1/8$ inch or 10 gage. The unit working stress shall be not more than $72 \frac{1}{2}$ percent of the specified minimum yield strength of the material furnished but in no case more than 36,000 pounds per square inch. A strip of $1/8$ -inch asphalt felt the same width as the angle shall be placed between the support angle and the deck panel. When cast-in-place slab concrete is to be used to provide permanent support for panels, concrete shall be placed in continuous strips over the girders and consolidated to ensure concrete penetrates under the panels prior to placing concrete on top of the panels. Slab overlay concrete shall penetrate under the panels to a width of $3 \pm 1/4$ inches and a thickness of at least $1 \frac{1}{2}$ inches to provide the rigid support for the panels. If this method of support is used, bridge seat elevations shall be adjusted as necessary at the Contractor's expense.
- (3) Welding and welds shall conform to the requirements of Section 407.04 except that $1/8$ -inch fillet welds will be permitted. Welding to beam or girder flanges will not be permitted.

Regardless of the method of support used, the Contractor shall ensure the stability of the deck panels until the slab overlay concrete has set.

- (b) **Falsework and Centering:** The Contractor shall have a Professional Engineer (holding a valid license to practice engineering in the Commonwealth of Virginia) inspect the completed falsework assembly supporting a bridge superstructure prior to placing loads. The Professional Engineer shall provide a certification, based upon visual inspection of the completed falsework assembly, that the falsework assembly conforms to the approved working drawings. However, such certification shall not require an exhaustive inspection or testing or make the Professional Engineer liable for any deficiencies in workmanship or materials by the Contractor or for such conditions that cannot be ascertained from a visual inspection.

Falsework shall be designed and constructed to provide the necessary rigidity and to support the loads without appreciable settlement or deformation. The Contractor may be required to employ screw jacks or hardwood wedges to take up settlement in the formwork either be-

fore or during concrete placement. A design weight of 150 pounds per cubic foot shall be assumed for fresh concrete.

Falsework that cannot be founded on a satisfactory footing shall be supported on piles that are spaced, driven, and removed in a manner approved by the Engineer.

Falsework shall be set in a manner so that after its removal the finished structure will have the finished grade specified or indicated on the plans. Correction for dead-load deflection of cast-in-place concrete beams and slab spans shall be provided for by applying an upward parabolic camber having an ordinate at midspan of 1/8 inch per 10 feet of span length.

Falsework-supporting elements shall remain in place until concrete in the element has attained at least the minimum 28-day design compressive strength.

Arch centering shall be constructed according to centering plans approved by the Engineer. Provision shall be made by means of suitable wedges, sand boxes, or other devices for gradual lowering of centers and rendering the arch self-supporting. When directed by the Engineer, centering shall be placed on approved jacks to take up and correct settlement that may occur after concrete placement has begun.

- (c) **Placement and Consolidation:** Individual placements of more than 25 yards of concrete shall be at the following rate:

Quantity (cu yd)	Min. Placement Rate
26–80	25%/hr
Over 80	20 cu yd/hr

If corrugated metal bridge deck forms are used in lieu of removable forms, concrete placement shall proceed in the direction opposite that of form placement.

Concrete shall be placed as soon as practicable after forms are prepared and excavation is completed. Water shall be removed from excavations before concrete is placed. Flowing water within the excavation shall be diverted outside concrete areas to a sump.

Before concrete is placed, sawdust, chips, dirt, and other debris and temporary struts and braces shall be removed from the space to be occupied by concrete. Removable forms shall be thoroughly wetted, oiled, or treated with an approved form-coating material. The depth and character of foundations and the placing of reinforcing steel shall have been approved by the Engineer.

Concrete shall be placed in forms immediately after mixing. Concrete that does not reach its final position in forms within the time specified in Section 217 shall not be used. The method of placement shall be such as to avoid the possibility of segregating ingredients and displacing reinforcement or void forms.

The use of long chutes for conveying concrete from the mixing plant to forms will be permitted only with the written permission of the Engineer. If chutes are allowed and the quality of concrete as it reaches the forms or the methods of placing it therein are not satisfactory, the Contractor shall, upon direction from the Engineer, discontinue the use of chutes and re-equip his operation for placing concrete in a satisfactory manner.

Where steep slopes are required, chutes shall be equipped with baffle boards. When pipes are used, they shall be kept full of concrete and have their lower ends buried in fresh concrete where necessary to prevent an excessive flow rate. Chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete by thorough flushing with water after each run. Water used for flushing shall be discharged clear of concrete in place and filtered prior to entry into state waters. Open troughs and chutes shall be metal or lined with metal and shall extend as nearly as possible to the point of deposit. When discharge must be intermittent, a hopper or other device for regulating discharge shall be provided.

Dropping concrete a distance of more than 5 feet or depositing a large quantity at any point and running or working it along forms will not be permitted. However, the 5-foot limitation will not apply to dropping concrete into forms for walls of box culverts, catch basins, drop inlets, or endwalls unless there is evidence of segregation.

Concrete placement shall be regulated so that pressures caused by fresh concrete shall be not more than those used in the design of forms.

Embedded materials shown on the plans shall be installed during each stage of concrete operations and suitably supported and maintained in the correct position. Reinforcement shall be placed in accordance with the requirements of Section 406.03(d).

Care shall be taken to fill each part of a form by placing concrete as near its final position as possible, working coarse aggregates back from forms, and moving concrete under and around reinforcing bars without displacing them. After concrete has taken its initial set, care shall be taken to avoid jarring forms or placing strain on ends of projecting reinforcement.

Concrete shall be thoroughly consolidated during and immediately following placement. Consolidation shall be accomplished by mechanical vibration subject to the following provisions:

1. Vibration shall be internal to the concrete but not applied directly to reinforcement or formwork.
2. Vibrators shall be of a type and design approved by the Engineer.
3. The intensity of vibration shall visibly affect a mass of concrete over a radius of at least 18 inches.
4. The Contractor shall provide a sufficient number of vibrators to consolidate each batch immediately after it is placed in forms.
5. Vibrators shall be manipulated to work concrete thoroughly around reinforcement and embedded fixtures and into corners and angles of forms. Vibration shall be applied at the point of deposit and in the area of the freshly placed concrete. Vibrators shall not be pulled through concrete and shall be inserted and withdrawn slowly and maintained nearly vertical at all times. Vibration shall be of sufficient duration and intensity to consolidate concrete thoroughly but shall not be continued so as to cause segregation. Vibration shall not be continued at any one point to the extent that localized areas of grout are formed. Application of vibrators shall be at points uniformly spaced and not further apart than twice the radius over which the vibration is visibly effective.

6. Vibration shall not be applied directly or indirectly to sections or layers of concrete that have hardened to the degree that it ceases to be plastic under vibration. Vibration shall not be used to make concrete flow in forms, and vibrators shall not be used to transport concrete in forms.
7. Vibration shall be supplemented by such spading as is necessary to ensure smooth surfaces and dense concrete along form surfaces and in corners and locations inaccessible to vibrators.
8. These specifications shall apply to filler concrete for steel grid floors except that vibration shall be applied to the steel.
9. These specifications shall apply to precast piling, concrete cribbing, and other precast units except that the manufacturer's methods of vibration may be used if approved by the Engineer.

When vibrating is not practicable, concrete shall be consolidated and its faces well spaded by continuous working with a suitable tool in a manner acceptable to the Engineer.

Concrete shall be placed in continuous horizontal layers not more than 12 inches in thickness. However, slabs shall be placed in a single layer. When it is necessary in an emergency to place less than a complete horizontal layer in one operation, the layer shall terminate in a vertical bulkhead. In any given layer, separate batches shall follow each other so closely that each one shall be placed and consolidated before the preceding one has taken initial set. Each layer of concrete shall be left rough to secure efficient bonding with the layer above. A succeeding layer placed before the underlying layer has become set shall be consolidated in a manner to prohibit the tendency to produce a construction joint between layers.

Layers placed at the end of one day's work or prior to temporarily discontinuing operations shall be cleaned of laitance and other objectionable material as soon as the surface has become sufficiently firm to retain its form. The top surface of concrete adjacent to forms shall be smoothed with a trowel.

Horizontal layers located to produce a construction joint at a location wherein a feather edge might be produced in the succeeding layer shall be formed by inset formwork so that the succeeding layer will end in a body of concrete having a thickness of at least 6 inches.

The work on any section or layer shall not be stopped or temporarily discontinued within 18 inches below the top of any face unless the details of the work provide for a coping having a thickness of not more than 18 inches, in which case the construction joint may be made at the underside of the coping at the option of the Engineer.

Care shall be taken when placing concrete to avoid coating reinforcing steel, structural steel, forms, and other items that extend into areas to be involved in a subsequent placement. If coating of steel does occur, no attempt shall be made to remove the mortar until after the concrete steel bond of the earlier placement has developed sufficiently to withstand a cleaning operation. Any coating of mortar on deformed bars that can-

not be removed by hand brushing with a wire bristle brush or a light chipping action will not have to be removed.

The method and manner of placing concrete shall be regulated so as to place construction joints across regions of low shearing stress and in locations that will be hidden from view to the greatest extent possible.

Placing and consolidating concrete shall be conducted to form a compact, dense, impervious mass of uniform texture that will show smooth faces on exposed surfaces. Any section of concrete found to be defective shall be removed or repaired as directed by the Engineer.

If concrete operations are permitted to extend after sunset, the work area shall be brightly lighted so that all operations are plainly visible.

1. **Culverts:** Sidewalls of box culverts shall be carefully bonded to the base slab in accordance with (h) herein. Each wing shall be constructed as a monolith if possible. Construction joints, where unavoidable, shall be horizontal.
2. **Girders, slabs, and columns:** Concrete shall be placed by beginning at the center of the span and working toward the ends. Concrete in girders shall be placed uniformly for the full length of the girder and brought up evenly in horizontal layers.

The concrete floor and girders for each span of concrete through girder spans and concrete in T-beams, slab spans, and deck girders shall be placed monolithically.

If the finished top surface of a concrete unit being placed is not level, care in the method of vibration, the use of low-slump concrete, or other means shall be taken to prevent downgrade movement of newly placed concrete. Special attention shall be given to sloping slabs.

Concrete in columns shall be placed in one continuous operation. If cap forms are supported by falsework independent of columns or column forms or are otherwise designed so that no load is placed on columns, concrete may be placed in caps after the concrete in columns has set for at least 12 hours.

Concrete shall not be placed in the superstructure until column forms have been stripped sufficiently to determine the character of the concrete in the columns.

- (d) **Pneumatic Placement:** Pneumatic concrete placement will be permitted only when authorized by the Engineer and the method is approved by the Engineer. When permitted, placement shall be in accordance with the requirements of Section 412.
- (e) **Pumping:** Placing concrete by pumping will be permitted only when authorized by the Engineer and provided concrete is pumped through a conduit system that is not aluminum. Equipment shall be arranged such that no vibrations that might damage freshly placed concrete will occur. Equipment shall be thoroughly cleaned prior to use. The operation of the pump shall be such that a continuous stream of concrete without air pockets is delivered. If concrete remaining in the pipeline is to be used, it shall be ejected in such a manner that there will be no contamination of concrete or separation of ingredients.

- (f) **Depositing Concrete Under Water:** Concrete shall not be deposited in water except with the approval of the Engineer.

Concrete placed in water shall be Class T3. Concrete shall be carefully placed in a compact mass in its final position by means of a tremie or another approved method and shall not be disturbed after being deposited except as specifically provided herein. Still water shall be maintained at the point of placement.

A tremie shall consist of a tube having a diameter of at least 10 inches, constructed in sections having flanged couplings fitted with gaskets. The discharge end shall be closed at the start of work and entirely sealed at all times. The tremie tube shall be kept full to the bottom of the hopper. When a batch of concrete is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, always keeping it in the placed concrete. Concrete seal shall be placed continuously from start to finish. Concrete shall be placed at a rate of at least one vertical foot per hour over the entire area of the seal course. The surface of concrete shall be maintained in a horizontal plane within a tolerance of 6 inches at all times during placement. The tremie shall be supported so that its discharge end is freely movable over the entire work area, or multiple tremies shall be used. Vibration shall be used only when deemed necessary by the Engineer. Supports for tremies shall permit rapid lowering of discharge ends when necessary to retard or stop the flow of concrete. The method of placing the seal shall be subject to the approval of the Engineer prior to concrete placement.

Removal of water from cofferdams or other structures may proceed when the concrete seal has attained final set. Laitance or other unsatisfactory material shall be removed from the exposed surface by scraping and chipping with pneumatic or hand tools to an extent that will expose the aggregate for good bond with the footing to be cast upon it but not to an extent that will damage the concrete.

- (g) **Construction Joints:** Construction joints that are not detailed on the plans shall be placed as directed or approved by the Engineer. Shear keys or inclined reinforcement shall be used where necessary to transmit shear or bond the two sections together. Joints shall be constructed so that feather edging does not occur.

For construction joints in deck slabs, a 2 by 1 1/2-inch shear key shall be provided between mats of reinforcing steel.

Construction joints against which earth fill is placed shall be protected by a heavy coat of asphalt conforming to the requirements of Section 213 applied for a distance of 3 inches on each side of the joint and continuous throughout its length.

In construction joints exposed to view, a waterstop conforming to the requirements of Section 213 shall be inserted. The waterstop shall be placed at least 3 inches from the face of the concrete and shall extend at least 2 inches into each section of concrete.

Longitudinal or transverse construction joints may be used to facilitate placing concrete in continuous slab spans. Longitudinal joints shall be spaced so that each concrete placement will be at least 10 feet in width. Transverse joints shall be placed at the centerlines of piers provided they are located infrequently, permitting simultaneous longitudinal screeding of as many spans as possible. Concrete shall be placed in one continuous operation between con-

struction joints. The volume of concrete in any one placement shall be not less than the volume of concrete in one end span.

- (h) **Bonding Construction Joints:** In joining fresh concrete to set concrete, the work already in place shall have its surface roughened thoroughly. Shavings, sawdust, and other loose and foreign material shall be removed. The surface shall be washed and scrubbed with wire brooms when necessary to remove substances that will interfere with bonding. Concrete of the preceding placement shall be thoroughly wetted prior to placement of the next unit of fresh concrete.

For construction joints in deck slabs, the vertical face shall be sandblasted to expose the coarse aggregate. When epoxy-coated reinforcing steel is used, the epoxy coating shall be protected during sandblasting operations. Damaged areas of coated bars shall be repaired in accordance with the requirements of Section 223. Prior to placement of adjoining concrete, the vertical face shall be coated with epoxy, Type EP-4. After the concrete in the second placement has set, a V groove shall be formed along the top of the joint by sandblasting to a depth of at least 1/4 inch and shall be sealed with epoxy, Type EP-5, low viscosity, conforming to the requirements of Section 243.

To bond successive courses, suitable keys shall be formed at the top of the upper layer of each day's work and at other levels where work is interrupted. Keys shall be formed by inserting and subsequently removing beveled wood strips, which shall be saturated with water to induce swelling prior to insertion in fresh concrete. At the discretion of the Engineer, rough stone or steel dowels may be used in lieu of keys. Dowels shall extend an equal distance on each side of the construction joint. Prior to the inserting or driving of dowels into predrilled or preformed holes, holes shall be filled with hydraulic cement grout in the proportion of 1 part cement to 2 parts sand. The size and spacing of keys and dowels shall be determined by the Engineer.

- (i) **Concrete Exposed to Tidal Water:** Concrete structures other than box culverts subject to the action of tidal water shall not have construction joints located within a zone 5 feet above to 5 feet below the elevation of the mean tide.

Concrete within 5 feet of the mean tide shall be cured in forms for 48 hours and allowed to dry for 5 days after forms are stripped. After drying, one coat of primer and four coats of asphalt, conforming to the requirements of Section 213, shall be applied during a period of 48 hours. Each coat shall be allowed to set before the succeeding one is applied. In lieu of primer and asphalt, the coating may consist of one coat of epoxy, Type EP-3B, followed by one coat of epoxy, Type EP-3T, and shall have a total thickness of at least 20 mils.

For precast concrete, protective coatings shall be applied in the same manner, but the seal coat shall be allowed to dry 4 days, or as long as necessary to harden, before handling.

Requirements for protective coating shall also apply to inside surfaces of box culverts that are subject to the ebb and flood of tidal water.

Concrete exposed to the action of ice, drift, or other forces producing shock and abrasion shall be protected by encasing that portion of the exposed surface with a special sheathing or protective armor. Provision shall be made in the size of the original cofferdam for sufficient clearance to permit access to the concrete surface for the installation and effective anchorage of the sheathing.

- (j) **Removing Formwork and Forming for and Placing Superimposed Elements:** In the determination for removing formwork and constructing superimposed elements, consideration shall be given to the location and character of the structure, the weather, other conditions influencing the setting of the concrete, and materials used in the mixture. Formwork shall include forms, braces, ties, guy wires, and other instruments of stabilization.

1. **Formwork** may be removed as follows:

- a. **Side forms or elements not immediately subjected to loading** (for example: footings and walls or columns with height to width ratios less than 10:1 [$h/w < 10:1$]): 48 hours or 30 percent concrete strength (f_c). For the purposes herein, width will be considered the narrowest portion of the element measured horizontally across its surface.

The time period noted for form removal shall begin at the completion of the concrete placement and is exclusive of hours when any portion of the surface of the concrete element is below 40 degrees F.

- b. **All other elements:** 60 percent concrete strength (f_c).

2. **Forming for superimposed elements** may be as follows:

- a. **Elements not immediately subjected to loading** (for example: footings and walls or columns with height to width ratios less than 10:1 [$h/w < 10:1$]): 48 hours or 30 percent concrete strength (f_c). For the purposes herein, width will be considered the narrowest portion of the element measured horizontally across its surface.

The time period noted for forming for superimposed elements shall begin at the completion of the concrete placement and is exclusive of hours when any portion of the surface of the concrete element is below 40 degrees F.

- b. **All other elements:** 60 percent concrete strength (f_c).

3. **Placing concrete in forms for superimposed elements** shall not be done until concrete has attained 60 percent concrete strength (f_c) except for footings, where concrete may be placed when the footing has attained 40 percent concrete strength (f_c).

The Contractor may submit calculations to show that lower strength requirements may be used but may not proceed to use these requirements before receiving written permission to do so from the Engineer.

Concrete strength (f_c) is the design minimum laboratory compressive strength at 28 days as specified in Table II-17 for the class of concrete designated. If the time for removing formwork and forming for or placing concrete in superimposed elements is determined by control cylinder strengths, the Contractor will be permitted to perform these operations when the control cylinder strengths reach the values previously specified. Control cylinders shall be cured under conditions that are not more favorable than the most unfavorable conditions for the portion of the concrete the cylinders represent. The Contractor shall furnish molds, labor, and materials; make sufficient test specimens; and transport specimens to the testing facility. Single-use wax paper, paper,

plastic, or light-gage metal molds conforming to the requirements of ASTM C470 may be used for making control cylinders. Control cylinders shall be molded under the observation of the Engineer. Tests for compressive strengths shall be performed by or under the supervision of the Engineer.

The concrete strengths and time periods noted herein for removing formwork or forming for or placing concrete in superimposed elements shall not apply to the use of equipment or other live loads on the structure. Stockpiling materials or using unauthorized equipment on the structure will not be permitted until conformance to the requirements of Section 404.03(m) has been attained.

Methods of form removal that will overstress the concrete shall not be used. Formwork and its supports shall not be removed without the approval of the Engineer. The Contractor shall ensure that proper curing as required by the Specifications is provided immediately after form removal.

Falsework shall conform to the requirements of Section 404.03(b).

- (k) **Curing Concrete:** The method of curing concrete shall be subject to the approval of the Engineer prior to mixing or placing concrete. When the atmospheric temperature is above 40 degrees F in the shade, concrete surfaces that are not protected by formwork and surfaces from which forms have been removed shall be cured using approved materials applied before the sheen disappears from fresh concrete or immediately upon removal of formwork. Concrete shall be cured for 7 days, regardless of the strength obtained with control cylinders. During this 7-day curing period, a curing agent or medium shall be used.

PE film used for curing shall be white except that opaque or transparent PE film may be used between November 1 and April 1.

When liquid membrane seal is used for curing grooved horizontal surfaces, the application rate shall be 100 to 150 square feet per gallon. The application rate for all other surfaces shall be 150 to 200 square feet per gallon. Application shall be such that an even, white, continuous membrane is produced on the concrete surface.

If the atmospheric temperature falls below 40 degrees F in the shade, water curing shall be discontinued except when it is accomplished by flooding as specified herein. Curing shall be immediately resumed using insulated blankets or other approved methods that will retain or supply moisture and maintain the temperature at the outermost surfaces of the concrete mass above 50 degrees F for at least 72 hours immediately following concrete placement and above 40 degrees F for at least 48 additional hours.

In the event the Contractor begins masonry concrete operations when the atmospheric temperature is below 40 degrees F in the shade, the method of cure and protection shall retain or supply moisture and maintain the temperature at the outermost surfaces of the concrete mass above 50 degrees F for at least 72 hours immediately following concrete placement and above 40 degrees F for at least 48 additional hours.

When concrete is cured by flooding with water and the temperature is below 40 degrees F in the shade, a depth of at least 6 inches shall be maintained above the surface of the mass until concrete has attained the minimum required design strength as determined by a test cylinder cured in the same water.

1. **Bridge Deck Curing:** Bridge deck concrete shall be moist cured with white PE sheeting with or without the use of wet burlap. The concrete shall be maintained in a moist condition by fogging after screeding and until covered with the sheeting. The concrete surface shall stay wet under the sheeting until the end of the moist-curing period. The moist-curing period shall be for at least 7 days and until 70 percent concrete strength (f'_{c}) is achieved. The initial temperature of the outermost surfaces of the concrete mass shall be above 50 degrees F for at least 72 hours and above 40 degrees F until the completion of the moist-curing period. When the sheeting is removed, burlap (if used) shall be removed also. White pigmented curing compound shall be applied at the rate of 100 to 150 square feet per gallon while the surface of the concrete deck is damp and free of standing water. Bridge deck overlay concrete shall be cured in accordance with the requirements of Section 412.
- (l) **Protecting Concrete:** Protection of concrete shall begin immediately following concrete placement in the formwork and shall continue without interruption throughout the curing period.
1. **Weather:** The Contractor shall schedule the placement of structural concrete so that the date and hour decided upon reflect consideration of weather conditions.

Concrete shall be protected from rain.

Concrete shall not be placed against surfaces whose temperature is below 40 degrees F. Concrete shall be protected from freezing by approved coverings and, when necessary, heating the surrounding air in such a manner that the concrete will not dry.

Protection shall be provided to prevent rapid drying of concrete as a result of low humidity, high wind, higher concrete temperatures than atmospheric temperatures, or combinations thereof. The Contractor shall perform evaporation rate testing for bridge deck placements and concrete overlays. Immediately after screeding and until the application of plastic sheeting and/or wet burlap, no surface of the freshly mixed concrete shall be allowed to dry. Fogging with pressure sprayers acceptable to the Engineer and sufficient to maintain a moist surface shall be required. The protective measures taken shall be sufficient to maintain an evaporation rate at or below 0.10 pound per square foot per hour for normal concrete bridge deck placements or 0.05 pound per square foot per hour for concrete overlays over the exposed surface of the concrete. Other preventative measures described in ACI 308 can be used in addition to fogging. Evaporation retardant films may be applied in a fine mist immediately after screeding to ensure that the surface remains wet until covered. If such materials are used, there shall be no disturbance of the concrete surface after placement of the retardant film and such film shall not be intermixed with the surface mortar. If plastic shrinkage cracking occurs due to the Contractor's negligence or failure to comply with specification requirements, the Engineer may direct the Contractor to make repairs by epoxy injections, concrete removal and replacement, or other methods approved by the Engineer at no additional cost to the Department.

2. **Construction activities:** Care shall be taken to avoid damage to concrete from vibration created by blasting and pile driving operations, movement of equipment in the vicinity of the structure, or disturbance of formwork or protruding reinforcement.

Concrete shall be protected from the heat of an open fire. A watchperson shall be provided at the structure throughout any period in which open-flame heaters are operated in the vicinity of the concrete.

After concrete in finished surfaces has begun to set, it shall not be walked on or otherwise disturbed for at least 24 hours except as provided for in (j) herein.

3. **Silicone treatment:** When unpainted weathering steel is used in a structure and no other concrete waterproofing surface finish is specified, a 5 percent solids, solvent-based, clear, water-repellent silicone treatment shall be applied in two coats to the surface of the concrete substructure on exposed concrete surfaces below and including the bridge seats, within the limits of vertical planes parallel to and 2 feet outside the extreme edges of exterior beams or girders. The first coat shall be applied at the rate of 60 to 70 square feet of surface area per gallon of treatment solution, and the second coat at the rate of 90 to 110 square feet per gallon. If the treatment is applied by spraying, the nozzle shall not be held further than 24 inches from the surface being treated. The treatment shall be applied after cleaning of exposed substructure concrete surfaces and before any structural steel is erected.
- (m) **Opening to Traffic:** Structures shall not be opened to traffic, including construction traffic, or used for storing materials before the concrete has attained the 28-day design compressive strength as specified in Table II-17. Cylinders used for control purposes shall be cured under conditions that are not more favorable than the most unfavorable conditions for the portions of concrete the cylinders represent. When traffic is to be permitted on a partially completed slab span, falsework shall remain in place in accordance with the strength requirements specified herein. Other structures supported on falsework from the ground shall not be opened to traffic until falsework is removed.

404.04—Bridge Deck Construction

Prior to the beginning of deck placement, screeds shall be approved by the Engineer.

When the longitudinal screed is used, the overall length shall be such as to screed independently supported spans up to and including 80 feet. The length of the screed shall be not less than the full length of the span for spans less than 80 feet. When using the longitudinal screed on independently supported spans exceeding 80 feet in length with a screed length less than the full length of the span, the center half of the span shall be completed first. Bulkheads or other substantial supports for the screed shall be placed over abutments and piers and at the terminal point of placements within the span. The surface of a previously placed section shall not be used as a bearing area for the screed track until control cylinders have attained a strength of at least 50 percent of f_c as specified in Table II-17.

When a transverse screed is used, the screed shall be of sufficient size to finish the full width of the deck between curbs or parapets unless a longitudinal joint in the deck is specified, in which case the portion on either side of the joint shall be placed and finished separately. Wheels of the screed shall bear on temporary rails supported on and directly above the main structural units or on form supports. With continuous spans, form supports shall be fully supported by the principal structural units supporting the deck. Rails shall be sufficiently rigid and strong to permit the screed to finish the surface of the deck within specified requirements. If rails are placed within the roadway area, they shall be elevated a sufficient distance above the deck to permit simultaneous finishing by hand of any portion not finished by the screed. Rail supports extending above the roadway surface shall be fabricated and

installed in a manner to permit their removal to at least 2 inches below the top surface of the deck slab. Where rail supports are placed in that portion of the deck under curbs or parapets, supports shall be placed so that they will be at least 2 inches from the face of the curb, parapet walls, or outside edge of the slab.

An approved positive means of permitting access to the surface of the bridge shall be provided for operations requiring access to the deck surface after passing of the screed. The means of access shall not make contact with the deck surface.

Concrete for the entire span or section to be placed shall remain workable until the entire operation of placing, screeding, patching, rescreeding, finishing, and testing is completed. Excess water or soupy material collected by a screeding operation shall be immediately removed from the deck.

If the concrete in the deck of a continuous beam or girder span group cannot be placed in one operation, the location of construction joints and sequence of placement shall be in accordance with the approved placement schedule. After the initial placement has been made in any one group of continuous spans, no further placement shall be made until previously placed concrete in the deck of that group has been in place for at least 3 days or until the cylinder strength is at least 0.4 f_c .

The deck surface shall be tested with a 10-foot straightedge and rescreeded as many times as is necessary to ensure a smooth riding surface. The straightedge shall be held in successive positions at the edges and quarter points and on the centerline, parallel thereto and in contact with the surface. Advancement along the deck shall be in successive stages of not more than the length of the straightedge. The surface shall also be checked transversely at the ends, quarter points, and center of the span. Areas showing high spots or depressions of more than 1/8 inch in 10 feet in the longitudinal direction and 1/4 inch in 10 feet in the transverse direction shall be struck off or filled with freshly mixed concrete. Attention shall be given to ensure that the surface across joints conforms to the requirements for smoothness.

404.05—Expansion and Fixed Joints

- (a) **Open Joints:** Open joints shall be constructed by inserting and subsequently removing wood strips, metal plates, or other approved material. Insertion and removal of the template shall be accomplished without chipping or breaking the corners of the concrete.

Edges of concrete adjacent to joints shall be finished to a radius of approximately 1/8 inch or as shown on the plans.

- (b) **Filled Joints:** Materials for filled joints shall conform to the requirements of Section 212 and shall be installed in accordance with the requirements of Section 316.04(m). When not specified or shown on the plans, filler shall be preformed asphalt joint filler and sealer shall be the hot-poured type.

Edges of concrete adjacent to joints shall be finished to a radius of approximately 1/4 inch or as shown on the plans.

When expanded rubber, PVC, or PE filler is used, it shall be attached to the first-placed side of the joint with an approved adhesive and the concrete on the other side shall then be placed against the filler. Care shall be taken not to displace or compress the filler.

Other types of premolded fillers shall be similarly placed but need not be attached by an adhesive.

Joints shall be free from cracked and spalled areas, and their faces shall be free from foreign matter, curing compounds, oil, grease, and dirt. Faces shall be sandblasted and the joint blown out with oil-free and water-free compressed air just prior to application of primer or sealer.

- (c) **Steel Joints:** Plates, angles, or other structural shapes shall be fabricated to conform to the section of the concrete floor. Fabrication and painting shall conform to the requirements of Section 407 and Section 411. Care shall be taken to ensure that the surface in the finished plane is true and free from warping. Positive methods shall be employed in placing joints to keep them in the correct position during concrete placement so that the opening at expansion joints shall be that designated on the plans at normal temperature. Care shall be taken to avoid impairing the clearance in any manner. Normal temperature shall be considered as 60 degrees F, and correction to this temperature shall be computed using a coefficient of expansion of 0.0000065 per foot per degree F.
- (d) **Waterstops:** Metal waterstops shall be spliced, welded, or soldered to form continuous, watertight joints.

Nonmetal waterstops shall be furnished full length for each straight portion of the joint without field splices. Manufacturer's shop splices shall be fully vulcanized.

Field splices for neoprene waterstops shall be vulcanized; mechanical, using stainless steel parts; or made with a splicing union of the same stock as the waterstop. Finished splices shall have a full-size tensile strength of 100 pounds per inch of width.

Field splices for PVC waterstops shall be made by heat sealing adjacent surfaces in accordance with the manufacturer's recommendations. A thermostatically controlled electric source of heat shall be used to make splices. The heat shall be sufficient to melt but not char the material.

When being installed, waterstops shall be cut and spliced at changes in direction as may be necessary to avoid buckling or distorting the web or flange.

If waterstops are out of position or shape after concrete is placed, the surrounding concrete shall be removed, the waterstop reset, and the concrete replaced, all at the Contractor's expense.

404.06—Bridge Seat Bearing Areas

Bridge seat bearing areas shall be finished plane and level and shall not deviate more than 1/16 inch from plane or more than 1/32 inch per foot from level or from the slope specified on the plans. These limits of tolerance do not necessarily represent fully acceptable construction but are the limits at which construction may become unacceptable. In general, workmanship on bearing areas shall be at a level of quality that will be well within the tolerance limits. Bearing area roughness for elastomeric pads shall conform to the requirements of Section 408.03(g).

Bearing areas shall be cleaned and tested for planeness and levelness prior to placement of bearing pads or preparation for bearing plates. Preparation of bearing areas for placing bearing plates and setting anchor bolts shall be in accordance with the requirements of Section 408.03(g) and (h).

404.07—Finishing Concrete Surfaces

Following replacement or satisfactory repair of defective concrete, surface defects produced by form ties, honeycombing, spalls, or broken corners or edges shall be cleaned, wetted, filled with a mortar conforming to the requirements of Section 218, and troweled or struck off flush with the surrounding surface. If the surface cannot be repaired immediately following removal of forms or before the concrete surface has become dry, the surface shall be kept wet for 1 to 3 hours, as directed by the Engineer, prior to application of mortar. Repaired areas shall be cured in accordance with the requirements of Section 404.03(k).

The formed face of the following concrete items shall be given a Class 1 finish: (1) bridge items: wheel guards, the inside and outside faces of parapet walls, and concrete posts and rails; and (2) other items: curbs, raised medians, steps, and retaining walls that lie within 30 feet of the edge of the pavement.

- (a) **Class 1, Ordinary Surface Finish:** Following removal of forms, fins and irregular projections shall be removed from exposed surfaces and surfaces to be waterproofed.

Immediately following removal of forms, surfaces that contain cavities having a diameter or depth greater than 1/4 inch shall be cleaned, wetted, filled with a mortar conforming to the requirements of Section 218, and rubbed with burlap. If the surface cannot be finished immediately following removal of forms or before the concrete surface has become dry, the surface shall be kept wet for 1 to 3 hours, as directed by the Engineer, prior to application of mortar. The finished surface shall be cured in accordance with the requirements of Section 404.03(k).

Construction and expansion joints in the completed work shall be left free from mortar and concrete. Joint filler shall be left exposed for its full length.

- (b) **Class 2, Rubbed Finish:** Rubbing of concrete shall be started immediately after forms are removed. Immediately before this work, concrete shall be kept wet for at least 3 hours. Sufficient time shall elapse before wetting to allow mortar used in the pointing of rod holes and defects to set thoroughly. Surfaces to be finished shall be rubbed with a medium-coarse carborundum stone with a small amount of mortar on its face. Mortar shall be composed of cement and fine aggregate mixed in the proportions used in the concrete being finished. Rubbing shall be continued until form marks, projections, and irregularities are removed; voids are filled; and a uniform surface is obtained. Paste shall be left in place.

The final finish shall be obtained by rubbing with a fine carborundum stone and water. Rubbing shall be continued until the entire surface has a smooth texture and uniform color.

After final rubbing is completed and the surface has dried, the surface shall be rubbed with burlap and left free from unsound patches, paste, powder, and objectionable marks.

- (c) **Class 3, Tooled Finish:** This finish shall be produced by the use of a bush hammer, pick, crandall, or other approved tool. Tooling shall not be done until concrete has set for at least

14 days and as much longer as may be necessary to prevent aggregate particles from being picked out of the surface. The finished surface shall show a grouping of broken aggregate particles in a matrix of mortar, with each aggregate particle in slight relief.

- (d) **Class 4, Sandblasted Finish:** The thoroughly cured concrete surface shall be sandblasted to produce an even, fine-grained surface in which mortar has been cut away, leaving the aggregate exposed.
- (e) **Class 5, Wire Brushed or Scrubbed Finish:** This finish shall be produced by scrubbing the surface of the plastic concrete with stiff wire or fiber brushes using a solution of muriatic acid in the proportion of 1 part acid to 4 parts water. As soon as forms are removed and while concrete is comparatively plastic, the surface shall be scrubbed thoroughly and evenly until the cement film or surface is removed and aggregate particles are exposed, leaving an even, pebbled texture presenting an appearance grading from that of fine granite to coarse conglomerate, depending on the size and grading of aggregate used. As soon as scrubbing has progressed sufficiently to produce the texture desired, the entire surface shall be thoroughly washed with water to which sufficient ammonia has been added to remove all traces of acid.
- (f) **Class 6, Bridge Deck Finish:** Methods, procedures, and equipment shall conform to the requirements of Section 404.03, shall not result in segregating ingredients of the concrete; and shall ensure a smooth riding surface.

Hydraulic cement concrete bridge deck surfaces shall be textured with uniformly pronounced grooves sawed transversely to the centerline. After final screeding of the deck, a multi-ply damp fabric shall be dragged over the deck surface to provide a gritty texture. The deck concrete shall not be grooved until it has reached an age of 14 days or 85 percent of the 28-day design compressive strength. Grooves shall be sawed approximately $3/16 \pm 1/16$ inch in depth and $1/8$ inch in width (nominal) on $3/4$ -inch (nominal) centers. Grooves shall terminate 12 ± 1 inches from the parapet wall or curb line. Grooves shall not be sawed closer than 2 or further than 3 inches from the edge of any joint. When the width of the cutting head on the grooving machine is such that grooves cannot be practically sawed to within the required tolerance for a skewed transverse joint, grooving shall not be closer than 2 inches or more than 36 inches from the edge of the joint. On curved decks, each pass of the grooving machine shall begin on the side of the deck having the smaller radius and the nominal spacing of grooves at the starting point shall be $3/4$ inch on center.

Bridge decks should be grooved prior to opening to traffic. However, the Contractor will be permitted to delay grooving up to 6 months. The Contractor shall provide the Engineer with a plan for traffic control when working under traffic.

If a single pass of the grooving machine cannot be made across the width of the bridge, the mating ends of subsequent passes shall not overlap previous grooves or leave more than 1 inch of surface ungrooved.

After concrete has set and prior to placement of other slabs, the deck surface will be tested by the Engineer. Areas showing high spots or depressions of more than the specified tolerances will be marked as failing to conform to smoothness requirements. Levels may also be run over the surface to determine if there is any deviation from grade and cross section. Decks that do not conform to thickness and surface smoothness requirements will not be ac-

cepted until deficiencies have been corrected as directed by the Engineer. Sections that cannot be satisfactorily corrected shall be removed and replaced at the Contractor's expense.

Bridge decks that are to receive an asphalt concrete overlay of 1 inch or more in thickness shall be finished to a tolerance of 1/4 inch in 10 feet in both longitudinal and transverse directions except at expansion joints, where the finished tolerance shall be 1/8 inch in 10 feet.

- (g) **Class 7, Sidewalk Finish:** After concrete has been placed, it shall be consolidated and the surface struck off with a strike board and floated with wooden or cork floats. Light metal marking rollers may be used if desired after the initial set. An edging tool shall be used on edges and at joints. The surface shall not vary more than 1/4 inch under a 10-foot straightedge and shall have a granular texture that will not be slick when wet.

404.08—Measurement and Payment

Concrete will be measured in cubic yards within the neat lines of the structure as shown on the plans and will be paid for at the contract unit price per cubic yard, complete-in-place. Deductions will not be made for chamfers 1 inch or less in width or for grooves less than 1 inch in depth. The volume of reinforcing steel or any other material or internal voids within the concrete will be deducted.

The volume of bridge deck slab concrete allowed for payment will be computed using the actual thickness of the slab, not to exceed the plan thickness plus 1/2 inch, for the area between faces of sidewalks, curb lines, railings, or parapets. The area beneath sidewalks, curbs, railings, or parapets will be based on the plan thickness. If prestressed concrete deck panel forms are used, the volume they displace will be computed using plan dimensions and the volume of the cast-in-place portion will be measured as provided herein.

Unless designated as pay items, this price shall include waterstops, waterproofing, damp-proofing, anchor bolts, drain assemblies, silicone treatment, protective coating for concrete exposed to tidal waters, and trial batches.

If corrugated metal bridge deck forms are used in lieu of removable forms, the price for concrete shall include furnishing and placing metal forms, additional concrete required to fill corrugations, work necessary to facilitate inspection of the underside of the deck, repairing deficiencies, and strengthening beams or girders to maintain the design live-load rating of the bridge. If prestressed deck panel forms are used in lieu of removable forms, the price shall include casting, furnishing, and placing forms.

Bridge-deck grooving will be measured in square yards of deck surface area from the faces of parapets, sidewalks, or curb lines and will be paid for at the contract unit price per square yard. No deduction will be made for drainage items and joints.

Payment will be made under:

Pay Item	Pay Unit
Concrete (Class) item	Cubic yard
Bridge-deck grooving	Square yard

SECTION 405—PRESTRESSED CONCRETE

405.01—Description

These specifications cover the use of prestressed or post-tensioned hydraulic cement concrete when called for on the plans.

405.02—Materials

- (a) **Concrete** shall conform to the requirements of Section 217, Class A5, with the following exceptions:
 1. Concrete for piles, beams, and slabs shall contain 3.5 gallons per cubic yard of calcium nitrite conforming to the requirements of Section 215 unless granulated iron blast-furnace slag (minimum 40 percent by weight) or silica fume (minimum 7 percent by weight) conforming to the requirements of Section 215 is used.
 2. Concrete for structures over tidal water, beams, and slabs within 15 feet of mean high tide and exposed piles shall contain either 5.4 gallons per cubic yard of calcium nitrite conforming to the requirements of Section 215 or 2.0 gallons per cubic yard of calcium nitrite with granulated iron blast-furnace slag (minimum 40 percent by weight) or silica fume (minimum 7 percent by weight.) conforming to the requirements of Section 215.
 3. Fully or partially embedded attachments to the prestressed concrete members required for supporting forms or stay-in-place deck panels shall be galvanized in accordance with Section 233.
- (b) **Concrete admixtures** shall conform to the requirements of Section 215.
- (c) **Epoxy-resin compounds** shall conform to the requirements of Section 243.
- (d) **Steel reinforcement and prestressed tendons** shall conform to the requirements of Section 223 and Section 406, respectively.
- (e) **Epoxy-coated reinforcing steel** shall conform to the requirements of Section 223.
- (f) **Structural steel** shall conform to the requirements of Section 226.
- (g) **Bedding materials and bearing pads** shall conform to the requirements of Section 237 and Section 408.
- (h) **Waterproofing** shall conform to the requirements of Section 416.
- (i) **Hydraulic cement mortar and grout** shall conform to the requirements of Section 218.

405.03—Plant Review

Plants that manufacture precast, prestressed concrete elements shall have PCI certification for applicable product groups and categories except that plants supplying only deck panels and piles will not be required to be certified. PCI inspection reports shall be on file at the plant and available for review by the Department. Plants that have not previously produced products for the Department will be inspected by the Engineer prior to commencement of production. The Contractor shall provide suitable office space for use by the Engineer's representatives.

The request for plant inspection shall be made by the Contractor to the Engineer at least 3 weeks prior to the start of production. As a part of the plant inspection, a meeting will be held with the producer, Contractor, Engineer, and Inspectors to discuss plant facilities, materials, production methods, drawings, and production schedules.

In order to qualify new installations for the manufacture of prestressed units other than piles, the Engineer may require the Contractor to test a unit that is representative of each design type and size of unit to be manufactured. The acceptance test shall be as follows: Not more than one line of units shall be cast prior to the satisfactory completion of the acceptance test. A representative unit shall be tested in accordance with the requirements of VTM-20 in the presence of the Engineer prior to plant approval.

The unit to be tested will be selected at random by the Engineer. Jigs and load-testing equipment shall be approved by the Engineer before use. The cost of the units selected for testing and the cost of the test shall be borne by the Contractor.

405.04—Concrete Controls

The Contractor shall provide concrete testing equipment and a Certified Concrete Technician to perform concrete acceptance tests.

During each concrete operation, at least two clusters of test cylinders shall be prepared. Each cluster shall consist of four 6 by 12-inch or six 4 by 8-inch cylinders, which shall be placed at quarter points of the casting bed and cured under the same conditions as the prestressed concrete units.

Concrete batches from which cylinders are made shall be tested for slump in accordance with the requirements of ASTM C143 and for air content in accordance with the requirements of ASTM C231.

The compressive strength of the concrete at strand release, as specified in Section 405.05(b), will be based on the results obtained from tests on one cylinder from each cluster.

Average values of test cylinders from each cluster will be used to determine acceptability of compressive strengths.

The Contractor shall maintain records of tensioning operations, curing temperatures, and concrete testing in a form suitable for permanent filing. Records shall be available to the Department and maintained for 10 years.

405.05—Procedures

- (a) **Forms:** Forms and centering shall be made and maintained true to the shapes and dimensions shown on the approved drawings.

Forms shall be of metal or other material that will give comparable results. Forms shall be designed and aligned so that they will not restrict the longitudinal movement of the casting when the prestressing force is transferred.

Drilled holes in bulkheads and templates shall be sized to provide for unrestricted movement of strands during tensioning.

Bulkheads may be constructed of adequately reinforced plywood. Wooden bulkheads that are warped or damaged shall not be used.

Form ties shall not be used without the approval of the Engineer.

Joints between panel forms shall be well aligned and tight, and adequate precautions shall be taken to prevent leakage of mortar. Corners or intersections of surfaces exposed in the completed structure shall be chamfered or rounded, with a width or radius of 3/4 inch. For square piles, corners shall be chamfered from 3/4 inch to 1 1/2 inches or rounded to a 2-inch radius. A smaller chamfer not less than 3/4 inch may be used if approved by the Engineer.

Void forms shall be anchored during concrete placement and secured by means other than being tied to strands.

Precast prestressed concrete box beams and flat slabs shall have one drain provided in each end of each void. The drain shall be located so that the void will drain after the unit has been installed in the structure. The device for forming the drain shall be of such material and design that the drain will not rust, stain, or otherwise disfigure the concrete and shall allow free drainage from the void.

- (b) **Placing Strands and Wires and Applying and Transferring Pretension:** The Contractor may be required to submit for approval the detailed computations of gage pressures and elongations proposed.

Wires shall conform to the requirements herein for strands.

When indicated on the plans and approved by the Engineer, the Contractor may substitute low-relaxation strands for stress-relieved strands or stress-relieved strands for low-relaxation strands in prestressed units provided the following conditions are met:

1. The unit is redesigned by the Contractor in accordance with the design specifications shown on the plans, including modifications by the Engineer.
2. There is no mixing of low-relaxation strands and stress-relieved strands within a superstructure, substructure, or piles.
3. In addition to the requirements specified in 1. and 2. herein, in prestressed piles, the net compressive stress in the concrete after all losses shall equal the stress for such piles as

shown on the plans, and the number and cross-sectional area of the strands in each pile shall equal or exceed the values shown on the plans.

When the Contractor elects to substitute low-relaxation strands for stress-relieved strands or stress-relieved strands for low-relaxation strands, the design, camber calculations, and working drawings shall be submitted in accordance with the requirements of Section 105.10.

Strands with kinks, bends, nicks, broken wires, scales, rust, or other defects shall not be used. The failure of one wire in a seven-wire pretensioned strand or one wire in a parallel-wire post-tensioned cable may be accepted provided the wire is not more than 2 percent of the total number of wires. Slight rusting will not be cause for rejection provided it is not sufficient to cause visible pits. Strands shall be satisfactorily cleaned before concrete operations begin.

Strands shall be placed in proper position and first tensioned individually by a force of at least 5 but not more than 25 percent of the final stressing force. This force shall not vary by more than 5 percent in any group of strands.

The final stressing of strands shall be performed by applying tension to each strand individually or to all strands as a group. The strand or strand group shall be tensioned to the total pretensioning force as indicated on the plans, with a maximum applied stress of 70 percent of the ultimate strength for stress-relieved strands and 75 percent of the ultimate strength for low-relaxation strands.

During stressing, allowance shall be made for the amount of strand anchorage slipping. The proper allowance shall be determined during trial plant operations and satisfactorily checked periodically during actual stressing operations. Strand anchorage devices of each type and source shall be checked as specified herein.

During stressing, allowance shall be made in the amount of strand elongation for the loss or gain in tension resulting from the change in temperature in the strand between the time of stressing and time of the initial set of concrete. The magnitude and method of application of this allowance shall be in accordance with the requirements of the *PCI Manual for Quality Control* (MNL-116).

A manufacturer's corresponding recommended value for the average modulus of elasticity will be used for each order of strand supplied. Consideration shall be given to the stress-strain data of tests performed on the samples.

Strands shall not be spliced within units.

Pretensioned strands shall be secured by suitable anchorage devices capable of developing at least 90 percent of the ultimate strength of the strand.

When deflected strands are tensioned in their deflected position, they shall be supported by lubricated rollers with solid bushings or other low-friction rollers at hold-up and hold-down points. Provisions shall be made for a cover of at least 1/8 inch of concrete or epoxy mortar on metal parts of the hold-down devices remaining in beams.

The final position of strands and reinforcing steel shall be accurately maintained as shown on the plans.

The tensioning system shall be equipped with a pressure gage indicating the jack pressure to an accuracy of within 2 percent of the pressure corresponding to the full prestress tension in the strand. Gages shall be recalibrated at least once every 6 months and any time the gaging system appears to be giving erratic or erroneous results or if the gage indication and elongation measurements indicate materially different stresses. Gages, jacks, and pumps shall be calibrated as a system in the same manner in which they are used in tensioning operations. Calibration shall be performed by an approved testing laboratory or approved calibration service, and a certified calibration curve shall accompany each tensioning system. Load, as measured by gage pressure, shall not vary from that measured by elongation by more than 5 percent. Elongation measurements shall be taken as checks on the final pressure gage reading. Elongation shall be measured to a precision of 1/4 inch. During stressing, elongation and pressure readings shall be recorded by the Contractor.

Tension in the strands shall not be transferred to the concrete in the unit until the concrete has attained a compressive strength of at least 3,500 pounds per square inch for piles and 4,000 pounds per square inch for other units. When multiple-strand detensioning is used, strands shall be transferred gradually, simultaneously, and equally to the concrete.

When the single-strand release method is used, strands shall be released by heating near the end of each unit in accordance with the Contractor's sequence and schedule. Individual jack release or burning may be used for strands at the dead or live end of the bed. Strands to be released in each step of the sequence shall be burned apart between beams before the next step is begun. No more than two strands shall be included in each step of the pattern.

Strands shall not be burned quickly but shall be heated with a low-oxygen flame played along the strand at least 5 inches until the metal gradually loses its strength and failure of the first wire in each strand occurs after the torch has been applied for at least 5 seconds.

The schedule for single-strand detensioning of units having deflected strands shall incorporate the following:

1. Straight strands located in the upper flange of the unit shall be released first.
2. Tension in the deflected strands at the ends of bed and uplift points shall be released in sequence.
3. Hold-down devices for deflected strands shall be disengaged, and hold-down bolts shall be removed from units.
4. The remaining straight strands of the pattern to be detensioned individually shall be released in sequence.

If it is desired to release hold-down devices prior to releasing tension in deflected strands, this may be permitted (1) if the weight of the prestressed unit is more than twice the total of the forces required to hold strands in the low position, or (2) if weights or other approved vertical restraints are applied directly over the hold-down points to counteract uplifting forces, at least until the release of deflected strands has proceeded to such a point that the residual uplifting forces are less than 1/2 the weight of the unit.

Failure to follow these procedures may result in rejection of units.

- (c) **Placing Concrete:** The procedure and equipment for handling, placing, and consolidating shall be such that a uniformly dense and high-grade concrete is obtained in all parts of the unit under all working and weather conditions.

When placing concrete in continuous horizontal layers in forms for precast I-beams, succeeding layers shall follow the preceding layer before any initial set takes place. Concrete in bottom slabs of precast prestressed box beams shall be placed before void forms are positioned. Concrete may be placed in forms for piling and precast slab units in one continuous horizontal layer.

The use of external vibration will be at the option of the Contractor. Improper placing and vibrating may be cause for rejection.

- (d) **Removing Forms:** Forms for units being moist cured may be removed when concrete reaches a strength of 1,500 pounds per square inch.

After forms are removed, units will be inspected to determine acceptability. Patching of any surface irregularities, especially those resulting from honeycombing, shall be performed only after inspection.

- (e) **Finishing:** Holes and voids in the surface of concrete resulting from bolts, ties, or large air pockets shall be wetted and filled with mortar having the same proportion of fine aggregate and cement as in the concrete, after which exposed mortar surfaces shall be finished smooth and even with a wood float.

If finishing work is necessary, the exterior face of exterior beams shall be finished free from blemishes and then rubbed with burlap. Holes or voids having a depth or diameter greater than 1/2 inch on the interior face of exterior beams, on both faces of interior beams, or on piles shall be filled and finished.

Surfaces to be repaired and finished shall be kept wet for at least 1 hour before hydraulic cement mortar is applied. Immediately following patching work, repaired areas shall be cured for at least 48 hours. The wet cure may be accomplished by the use of steam, wet burlap, or continuous spray wetting, or liquid membrane-forming compound may be used on noncomposite surfaces. Epoxy may be used and shall be applied and cured in accordance with the manufacturer's recommendations.

Piles specified on the plans as being subject to tidal waters shall be finished in accordance with the requirements of Section 404.03(i).

Tops of prestressed deck panels shall receive a finish having pronounced grooves. Grooves shall be approximately 1/8 inch in depth and 1/8 inch in width, with a spacing of not more than 1 inch. Other groove patterns proposed by the Contractor that promote bonding may be used upon written approval by the Engineer.

Units that are to be made composite with subsequently placed concrete shall be finished by striking off the top of forms. As soon as the condition of the concrete permits and before it has fully hardened, dirt, laitance, and loose aggregate shall be removed from the surface by means of a wire brush, which shall leave the coarse aggregate slightly exposed or otherwise

roughened. If concrete has been allowed to harden so that it is impossible to remove laitance and roughen the top surface of units by brushing, the surface shall be cleaned and prepared for bonding by chipping.

Except in piles, ends of strands shall be allowed to cool to normal temperature after cutting and then shall be covered with at least 1/8 inch of epoxy mortar or other material approved by the Engineer. After mortar is allowed to cure, the entire end of the unit shall be covered with epoxy, Type EP-3T.

Care shall be taken in cutting or burning ends of strands to prevent damaging the concrete surface.

- (f) **Protecting and Curing:** Prestressed concrete shall be cured by being kept moist at temperatures that will promote hydration. Proper curing by any method requires that moisture is retained for complete hydration and the formation of surface cracks attributable to rapid loss of water is prevented while the concrete is plastic. Prior to concrete placement, procedures for retaining moisture shall be approved by the Engineer. Moist curing shall continue until such time as the compressive strength of the concrete reaches the strength for detensioning. Moist curing shall commence as soon as possible following the completion of surface finishing.

The Contractor shall have the option of using steam curing in lieu of moist curing in accordance with the following:

1. The design concrete mixture shall be proven adaptable for steam curing using the same cure as proposed for the routine manufacture of prestressed concrete units.
2. The Contractor shall be responsible for the quality of concrete placed in any weather or atmospheric condition. At the time of placement, concrete shall have a temperature of 40 degrees F to 90 degrees F when concrete is moist cured. If accelerated curing is used, the temperature of the concrete at placement shall be 40 degrees F to 100 degrees F. Mixing limitations shall be in accordance with the requirements of Section 217.09.
3. An initial set of a nominal 500 pounds per square inch, determined by the penetration resistance test, shall be obtained prior to the introduction of steam. The penetration resistance test shall be performed in accordance with the requirements of ASTM C403. Forms shall be covered after surface finishing of the concrete, including the delay period before introduction of steam.
4. The temperature rise in the curing enclosure shall be uniform, with a rate rise of not more than 80 degrees F per hour. Concrete shall be cured at a steam temperature of not more than 180 degrees F, with the steam temperature uniform throughout the curing enclosure and with a variation of not more than 20 degrees F. Approved recording thermometers shall be placed so that temperatures can be recorded at a minimum of two uniformly spaced locations in each curing enclosure.
5. Steam curing shall be maintained until such time as the compressive strength of the concrete attains that specified on the plans for detensioning.
6. Steam curing shall be performed under a suitable enclosure to retain the live steam at 95 percent relative humidity and minimize heat losses. Enclosures shall allow free cir-

ulation of steam. Steam jets shall be positioned so that they will not discharge directly on concrete, forms, or test cylinders.

7. Concrete test cylinders shall be subject to the same curing conditions as the units.
 8. Immediately after steam curing is terminated, forms shall be loosened and the stress load on the stressing strands shall be released while the concrete is still hot.
- (g) **Waterproofing:** Units so designated on the plans shall be waterproofed in accordance with the requirements of Section 416.
- (h) **Handling, Storing, and Erecting:** Units shall be adequately separated in storage immediately following removal from beds to facilitate repair of surface blemishes and make inspection of finished surfaces possible.

Care shall be taken in handling and storing units to avoid damage to concrete. Concrete shall have attained the minimum 28-day design compressive strength before structural units are shipped to the project site.

Piles shall not be driven until at least 7 days after the date concrete is cast and has attained the minimum design compressive strength.

Lifting and support points for units other than piles and deck panels shall be as shown on the plans or not less than 6 inches or more than $2/3$ of the depth of the unit from the end of the unit. Piles and deck panels shall be supported and lifted at points shown on the plans. The Contractor shall be responsible for the design and safety of the lifting device used.

Requests to use lifting or support points other than those indicated must be accompanied by computations showing that stresses are within the allowable range using 50 percent of the dead load as an impact factor.

Units that have been damaged in handling shall be satisfactorily repaired.

Shear keys required between adjacent units, recesses at ends of transverse ties, holes for anchor bars, and other recesses shown on the plans shall be filled with mortar conforming to the requirements of Section 218. Mortar shall be applied in one continuous operation for each span.

Where waterproofing material is to be applied to tops of units in the field, longitudinal joints shall be sufficiently smoothed to prevent damage to the material.

Struts and diaphragms between spread units may be cast separately or monolithically with the deck slab. If the Contractor casts struts and diaphragms separately from the slab, the age or compressive strength of the concrete in the struts or diaphragms shall conform to the requirements for I-beams in Section 404.03(j) before deck slab concrete is placed. If the Contractor casts struts and diaphragms monolithically with the slab, each prestressed concrete beam shall be placed and restrained in such a manner that the beam will not be canted during construction of the struts, diaphragms, and slab. The Contractor's method for maintaining acceptable vertical alignment of beams shall be subject to the approval of the Engineer.

Bearing surfaces of units shall be parallel to the bottom surface of the unit or as specified on the plans. Attached bearing assemblies shall be fabricated so that their bottom bearing surfaces shall lie in truly horizontal planes in their erected position. Metal bearing plates or bottoms of precast beams that are to bear on elastomeric pads shall be coated with epoxy, Type EP-2, EP-4, or EP-5, and then surfaced with a No. 36 to No. 46 silicon carbide or aluminum oxide grit.

Ends of beams, at ends of spans, and diaphragms shall be vertical.

405.06—Tolerances

The limits of tolerance do not necessarily represent fully acceptable construction; they are the limits at which construction may become unacceptable. In general, workmanship shall be at a level of quality that will be well within the tolerance limits.

(a) Precast Prestressed Concrete I-Beams and T-Beams:

Characteristic	Values
Depth (overall)	±1/4 inch
Width (flanges and fillets)	±1/4 inch
Width (web)	±1/4 inch
Length of beam	±1/8 inch/10 ft or 1/2 inch, whichever is greater
Exposed beam ends (deviation from square or designated skew)	Horizontal ±1/4 inch, vertical ±1/8 inch/ft of beam height
Side inserts (spacing between centers of inserts and from centers of inserts to ends of beams)	±1/2 inch
Bearing plate (spacing from centers of bearing plates to ends of beams)	±1/2 inch
Stirrup bars (projection above top of beam)	±3/4 inch
Stirrup bars (longitudinal spacing)	±1 inch
Horizontal alignment (deviation from straight line parallel to centerline of beam)	Max. 1/8 inch/10 ft
Camber differential between adjacent beams of same type and strand pattern	1/8 inch/10 ft or max. 1/2 inch (at time of erection)
Camber differential from computed camber	±50% (at time of erection)
Center of gravity of strand group	±1/4 inch
Center of gravity of depressed strand group at end of beam	±1/4 inch
Position of hold-down points for depressed strands	±6 inches
Position of handling devices	±6 inches

(b) **Precast Prestressed Concrete Box Beams and Flat Slabs:**

Characteristic	Values
Depth (top slab)	+1/2 to -1/4 inch
Depth (bottom slab)	0 to +1/2 inch
Depth (overall)	±1/4 inch
Width of web or thickness of sidewalls	±3/8 inch
Width (overall)	+1/8 to -1/4 inch
Length	±1/8 inch/10 ft or 1/2 inch, whichever is greater
Void position (longitudinal)	±1/2 inch adjacent to tie holes ±1 inch adjacent to end block
Square ends (deviation from square)	±1/4 inch
Skew ends (deviation from designated skew)	
Skew angle equal to or less than 30°	±1/4 inch
Skew angle greater than 30°	±1/2 inch
Horizontal alignment (deviation from straight line parallel to centerline of unit)	Max. 1/8 inch/10 ft
Gap between adjacent units	Max. 1/2 inch
Tie rod tubes (spacing between centers of tubes and from centers of tubes to ends of units)	±1/4 inch
Tie rod tubes (spacing from centers of tubes to bottom of beam)	±1/4 inch
Camber differential between adjacent units	Max. 1/4 inch (at time of erection)
Camber differential between high and low units in same span	Max. 3/4 inch (at time of erection)
Camber differential from computed camber on plans	±50 percent (at time of erection)
Side inserts (spacing between centers of inserts and from centers of inserts to ends of beams)	±1/2 inch
Stirrup bars (projection above top of beam)	±3/4 inch
Stirrup bars (longitudinal spacing)	±1 inch
Center of gravity of strand group	±1/4 inch
Center of gravity of depressed strand group at end of beam	±1/4 inch
Position of hold-down points for depressed strands	±6 inch
Position of handling devices	±6 inch

(c) **Prestressed Deck Panels:**

Characteristic	Values
Width (perpendicular to strand)	0 to +1/2 inch
Length (in direction of strand)	0 to 1/2 inch
Distance of at least 1/2 inch shall be maintained between deck panel and shear connectors or shear reinforcing steel connecting deck panel to beam.	
Depth	0 to +1/4 inch
Distance between centerline of strands and bottom of panel	0 to -1/4 inch

(d) **Prestressed Concrete Piling:**

Characteristic	Values
Width or diameter	-1/4 to +3/8 inch
Head out of square	1/16 inch/12 inch of width
Length of pile	±1 1/2 inch
Horizontal alignment (deviation from straight line parallel to centerline of pile)	Max. 3/16 inch/20 ft of length Max. 1/8 inch in 10-ft chord Max. 1/16 inch in 1 ft
Void location	±1/4 inch
Stirrup bars or spiral position	±1 inch
Center of gravity of strand group	±1/4 inch
Position of handling devices	±6 inch

405.07—Measurement and Payment

Prestressed concrete piles will be paid for in accordance with the requirements of Section 403.08.

Prestressed concrete structural units that are to be incorporated in the completed structure will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each.

These prices shall include manufacturing and furnishing units complete-in-place in the structure; mortar seals on ends of units; structural and reinforcing steel for connecting units to struts and diaphragms; reinforcing, structural, and prestressing steel embedded in units, including dowels in place and bearing pads or bearing devices, post-tensioning fittings, strands, and rods; grouting; joint fillers and sealers; waterproofing applied to structural units at the prestressing plant; hauling; handling; and treatment.

Prestressed concrete panels will be measured in square feet of surface area, complete-in-place, and will be paid for at the contract unit price per square foot. This price shall include manufacturing, furnishing, and installing.

Payment will be made under:

Pay Item	Pay Unit
Prestressed concrete (Shape, beam, description of cross section, and length)	Each
Prestressed concrete slab (Width, depth, and length)	Each
Prestressed concrete panel (Depth)	Square foot

SECTION 406—REINFORCING STEEL

406.01—Description

This work shall consist of furnishing; coating, if required, and placing reinforcing steel or wire mesh used in concrete operations, except prestressed strands and wires, in accordance with these specifications and in conformity to the lines and details shown on the plans.

406.02—Materials

- (a) **Steel used for reinforcement** shall conform to the requirements of Section 223. Except for spiral bars, bars more than 1/4 inch in diameter shall be deformed bars.
- (b) **Epoxy-coated bars** shall conform to the requirements of Section 223.
- (c) **Welded wire fabric** shall conform to the requirements of Section 223.
- (d) **Bar mat reinforcement** shall conform to the requirements of Section 223.

406.03—Procedures

- (a) **Order Lists and Bending Diagrams:** Copies of order lists and bending diagrams shall be furnished the Engineer when required.
- (b) **Protecting Material:** Reinforcing steel shall be stored on platforms, skids, or other supports that will keep the steel above ground, well drained, and protected against deformation.

When placed in the work, steel reinforcement shall be free from dirt, paint, oil, or other foreign substances. Steel reinforcement with rust or mill scale will be permitted provided samples wire brushed by hand conform to the requirements for weight and height of deformation.

Upon delivery to the project site, epoxy-coated reinforcing steel shall be covered with an opaque covering. In addition, epoxy-coated reinforcing steel that has been partially embedded in concrete or placed in formwork and not covered with concrete shall have the exposed surfaces covered with an opaque covering after 30 days exposure to sunlight. The opaque coverings shall be placed in a manner to provide air circulation and prevent condensation on the reinforcing steel.

- (c) **Fabrication:** Bent bar reinforcement shall be cold bent to the shape shown on the plans. Fabrication shall be in accordance with the requirements of the *Manual of Standard Practice for Detailing Reinforced Concrete Structures* (ACI 315).

Spiral bars shall be fabricated to have the proper diameter when placed in position at the pitch shown on the plans. Each end of a spiral bar shall have 1 1/2 finishing turns at each end in a plane perpendicular to the axis of the spiral.

- (d) **Placing and Fastening:** Steel reinforcement shall be firmly held during the placing and setting of concrete. Bars, except those to be placed in vertical mats, shall be tied at every intersection where the spacing is more than 12 inches in any direction. Bars in vertical mats and in other mats where the spacing is 12 inches or less in each direction shall be tied at every intersection or at alternate intersections provided such alternate ties accurately maintain the position of steel reinforcement during the placing and setting of concrete.

Tie wires used with epoxy-coated steel shall be plastic coated or epoxy coated.

Following placement of epoxy-coated reinforcement and prior to concrete placement, the reinforcement will be inspected. All visible damage of the epoxy coating shall be repaired in accordance with the requirements of Section 223.

The minimum clear distance from the face of the concrete to any reinforcing bar shall be maintained as specified herein. In superstructures, the cover shall be at least 2 1/2 inches except as follows:

1. **Bottom of slab:** 1 1/4 inches.
2. **Stirrups and ties in T-beams:** 1 1/2 inches.
3. **Rails, rail posts, curbs, and parapets:** 1 inch.

In substructures, the cover shall be at least 3 inches except as follows:

1. **Abutment neat work and pier caps:** 2 1/2 inches.
2. **Spirals and ties:** 2 inches.

In corrosive or marine environments or under other severe exposure conditions, the minimum cover shall be increased 1 inch except where epoxy-coated reinforcement is used. Bars that must be positioned by maintaining clearances from more than one face shall be centered so that clearances indicated by the plan dimension of bars are equalized.

Bars shall be placed so that the concrete cover as indicated on the plans will be maintained within a tolerance of 0 to +1/2 inch in the finally cast concrete.

Where anchor bolts interfere with reinforcing steel, the steel position shall be adjusted without cutting to permit placing anchors in their proper locations.

Reinforcement in bridge deck slabs and slab spans shall be supported by standard CRSI metal or precast concrete bar supports. Bar supports shall be spaced as recom-

mended by CRSI but not more than 4 feet apart transversely or longitudinally. Precast concrete supports shall be less than 1 foot in length and staggered so as not to form a continuous line. The lower mat of steel reinforcement shall be supported by a bolster block or individual bar chair supports, and the upper mat shall be supported by high chair supports. Bar supports shall be firmly stabilized so as not to displace under construction activities. Reinforcing bar supports (Standees) may be used for the top mat of steel of simple slab spans provided they hold the reinforcing steel to the requirements specified herein and are firmly tied to the lower mat to prevent slippage. The use of standees will not be permitted for the top mat of steel on any continuous slab spans.

Precast concrete bar supports shall have a 28-day design compressive strength of at least 4,500 pounds per square inch and shall be from the Department's list of approved products for the use specified. Supports shall be furnished with epoxy-coated or plastic ties or shaped to prevent slippage from beneath the reinforcing bar. Metal bar supports shall be fabricated from one of the following: (1) stainless steel wire conforming to the requirements of ASTM A493, or (2) cold-drawn wire protected by plastic coating conforming to CRSI standards, epoxy coating, or other protective coating as approved by the Engineer.

In reinforced concrete sections other than bridge slabs, the specified clear distance from the face of concrete to any reinforcing bar and the specified spacing between bars shall be maintained by means of approved types of stays, ties, hangers, or other supports. The use of pieces of gravel, stone, brick, concrete, metal pipe, or wooden blocks will not be permitted as supports or spacers for reinforcing steel. The use of precast concrete block supports will be permitted provided blocks are furnished in correct thicknesses and are shaped or tied to prevent slippage from beneath reinforcing bars. The clear distance between bars shall be at least 1 1/2 times the specified maximum size of coarse aggregate but not less than 1 1/2 inches. Before concrete is placed, reinforcing steel will be inspected and approved for proper position and the adequacy of the method for maintaining position.

- (e) **Splicing and Lapping:** Reinforcement shall be furnished in full lengths as indicated on the plans. Except where shown on the plans, splicing bars will not be permitted without the written approval of the Engineer. Splices shall be as far apart as possible.

Bars shall be lapped at least 30 bar diameters to make the splice. In lapped splices, bars shall be placed in contact and wired together. Mechanical butt splicing will be permitted at longitudinal joints in deck slabs and other locations shown on the plans provided the mechanical connection develops in tension or compression, as required, at least 125 percent of the specified yield strength of the bar. Reinforcing steel shall be welded only if specified on the plans. Welding shall be in accordance with the requirements of Section 407.04(a).

Laps for sheets of welded wire fabric or bar mat reinforcement shall be at least one mesh in width.

406.04—Measurement and Payment

Reinforcing steel will be measured in pounds of steel placed in the structure as shown on the plans. The weight of **welded wire fabric** will be computed from the theoretical weight per square yard placed, including allowance for laps not to exceed 8 percent of the net area. Reinforcing steel or weld-

ed wire fabric will be paid for at the contract unit price per pound. These prices shall include furnishing, fabricating, and placing reinforcement in the structure. In structures of reinforced concrete where there are no structural steel contract items, expansion joints, plates, rockers, bolts, and similar minor metal parts will be paid for at the contract unit price for reinforcement.

Epoxy-coated reinforcing steel, when a pay item, will be measured in pounds of uncoated steel and will be paid for at the contract unit price per pound. The weight will be computed from the theoretical weights of the nominal sizes of steel specified and placed in the structure. Measurement will not be made for epoxy-coating material. This price shall include furnishing steel and epoxy-coating material; applying coating material; fabricating, shipping, and placing epoxy-coated reinforcement in the structure; and necessary repairing of epoxy coatings. When the Contractor elects to eliminate the epoxy coating of reinforcing steel and furnish a latex hydraulic cement concrete deck surface, payment will be made at the same contract unit price as if epoxy-coated reinforcing steel had been used.

No payment will be made for fastening devices that may be used by the Contractor for keeping reinforcing bars in their correct position. When the substitution of larger bars than those specified is allowed, payment will be made for only the amount of metal that would have been required if the specified size of bar had been used. When full-length bars are shown on the plans and the Contractor obtains approval to use short bars for his convenience, the weight paid for will be based on the full-length dimensions with no allowance made for splices.

Payment will be made under:

Pay Item	Pay Unit
Reinforcing steel	Pound
Welded wire fabric	Pound
Epoxy-coated reinforcing steel	Pound

SECTION 407—STEEL STRUCTURES

407.01—Description

This work shall consist of furnishing, fabricating, and erecting steel materials in accordance with these specifications and in conformity with the lines, grades, and dimensions shown on the plans or as established by the Engineer.

407.02—Materials

Materials shall conform to the requirements of Section 226.

407.03—Working Drawings

The Contractor shall submit for review by the Engineer working drawings of all structural steel, bearing assemblies, and anchorage devices. Details shown on the drawings shall conform to these specifications and the requirements of the Structural Steel Design Section of AASHTO's *Standard Specifi-*

cations for Highway Bridges. In addition, primary stress units shall be detailed and identified by an individual piece mark. The review of working drawings shall not relieve the Contractor of responsibility for errors on the drawings or deviations from the plans unless such changes are approved in writing by the Engineer. Shop work shall not be performed until after the working drawings have been reviewed.

The Contractor may, in writing, authorize the fabricator to act for him in matters relating to working drawings in accordance with the requirements of Section 105.10.

Working drawings shall specifically identify each piece other than steel conforming to the requirements of ASTM A 709, Grade 36. Pieces fabricated of different grades of steel shall not be given the same piece mark, even if they have identical dimensions and details.

407.04—Fabrication Procedures

Workmanship, finish, and fabrication tolerances shall conform to AISC standards except where the standards are in conflict with these specifications. Where AISC standards allow alternate methods of fabrication, the method used shall be that which produces the higher quality of workmanship and finish.

Structural steel shall be fabricated in a shop certified by AISC, Category SBR or CBR, with endorsements for fracture critical and/or painting as appropriate.

Fabrication and welding of structural steel bridge units shall conform to the requirements of these specifications and AASHTO/AWS Bridge Welding Code D1.5. Structural components designated in the contract documents as fracture-critical shall conform to the provisions of the AASHTO/AWS Bridge Welding Code D1.5, Section 12, Fracture Control Plan (FCP) for Non-redundant Members.

Fabrication and welding of other structural and miscellaneous steel shall conform to the requirements of these specifications and AWS Structural Welding Code D1.1.

The Contractor shall give the Engineer ample notice of the beginning of work in the shop so that an inspection can be made. Work shall not be performed in the shop before the Engineer has been notified.

Steels shall be identified during fabrication as follows: The Contractor shall furnish a complete mill analysis showing chemical and physical results from each heat of steel for all units prior to fabrication. Each piece of steel shall be properly identified.

Before cutting, pieces of steel other than steel conforming to the requirements of ASTM A709, Grade 36, that are to be cut to smaller-sized pieces shall be legibly marked with the ASTM A6 specification identification color code or the material specification designation. The identification color code of the latest system adopted under ASTM A6 shall be used to identify material.

Upon request, the Contractor shall furnish an affidavit certifying that he has maintained the identification of steel in accordance with these specifications throughout the fabrication operation.

- (a) **Welds:** Only welding or tack welding noted on the plans shall be performed on structural steel, reinforcing steel, or aluminum units.

Structural units shall not be used as a worktable. Welding on other work shall be completed before parts are installed on units and shall conform to the following:

1. Groove welds in flange plates, cover plates, and longitudinal stiffeners shall be ground flush. Groove welds in legs of rigid frames, webs of exterior girders, and beams shall be ground flush on the exposed side. Cope holes shall not be filled. The perimeter of cope holes shall be ground smooth. Temporary erection bolt holes shall be filled with high-strength bolts and tightened in accordance with the specifications herein.
2. Electroslag and electrogas welding processes will be permitted only when pre-approved in writing by the Engineer.
3. Welds that do not conform to the requirements of the specifications, as determined by visual inspection or nondestructive testing, shall be repaired or removed and replaced by the methods permitted in the specifications or the entire piece will be rejected. Repaired or replaced welds will be reinspected in accordance with the applicable nondestructive testing method.
4. For each welder, welding operator, or tacker, the Contractor shall submit or shall have the fabricator submit to the Engineer a copy of the certificate of qualification and a certificate stating that the welder, welding operator, or tacker has not exceeded any period of 3 months since the date of qualification without performing satisfactory welding in the required process. The qualification certification shall state the name of the welder, operator, or tacker; name and title of the person who conducted the examination; type of specimens; position of welds; results of tests; and date of the examination. The qualification certification shall be made by an approved agency.

Welds for reinforcing steel, including tack welds, shall conform to the requirements of AWS D1.4.

Welding of aluminum shall conform to the requirements of AWS D1.2.

Welds for tubular structures shall conform to the requirements of AWS D1.1.

(b) **Straightening and Curving Rolled Beams and Plate Girders:**

1. **Straightening material:** Rolled material shall be straight before being laid off or worked. When straightening is required, it shall be done by methods that will not damage the metal. If straightening is performed by heating, heating shall be performed in accordance with 2. herein.

Sharp kinks or bends shall be cause for rejection of the material.

2. **Curving rolled beams and plate girders:** The Contractor shall submit a detailed procedure for the method of heat curving beams or girders.

Heat shall be applied so as to bring the steel to the temperature required for heat curving as rapidly as possible but not to more than 1200 degrees F. When any portion of a unit is heated to a temperature in excess of 1200 degrees F, the unit will be rejected.

- a. **Sequence of operations:** Units shall be cambered before heat curving and shall be heat curved in the fabrication shop before painting.

Longitudinal stiffeners shall be heat curved or cut separately and then welded to the curved units. When cover plates are to be attached to the rolled beams, they may be attached 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 more than 1,000 feet. For other rolled beams with cover plates, beams shall be heat curved before cover plates are attached. Cover plates may be either heat curved or cut separately and then welded to the curved beam.

- b. **Camber compensation:** To compensate for the loss of camber of heat-curved units in service having a radius of 800 feet or less, additional camber shall be provided in the units. The amount of additional camber at the midlength of the unit shall be C_h for units having a radius less than 500 and $1/2 C_h$ for units having a radius from 500 feet to 800 feet. C_h shall be computed as follows:

$$C_h = \frac{0.02L^2F_y}{EY_o}$$

Where:

L = the length, in inches, of the unit specified to be cambered

F_y = the specified minimum yield point of the flange in kips per square inch

E = the modulus of elasticity in kips per square inch

Y_o = the distance from the neutral axis to the extreme outer fiber in inches (maximum distance for nonsymmetrical sections).

The additional camber, C_h , at any other point in the unit shall be computed as follows:

$$C_h = \frac{C \times C_h}{C}$$

Where:

C = the camber specified at midlength in the design plans

C = the camber specified at any other point in the design plans.

The additional camber provided shall be shown on the working drawings.

- c. **Type of heating:** Where heat curving is permitted by the plans, plate girders and rolled beams may be curved by either continuous or V-type heating. Heat curving shall not be performed until camber conforms to the requirements of the specifications.

- (1) **Continuous method:** A strip along the edge of the top and bottom flange shall be heated simultaneously. The strip shall be of sufficient width and temperature to obtain the required uniform curvature.

(2) **V-type method:** The top and bottom flanges shall be heated in truncated triangular or wedge-shaped areas having their base along the flange edge and spaced at regular intervals along each flange. Spacing and temperature shall be as required to obtain the required uniform curvature. Heating shall progress simultaneously along the outside surface of the top and bottom flange. When the flange thickness is 1 1/4 inch or greater, heat shall be applied simultaneously to the inside flange surface (surface that intersects with the web) and outside flange surface.

- d. **Position for heating:** The unit may be heat curved with the web in the vertical or horizontal position. When curved in the vertical position, the unit shall be braced or supported so that the tendency of the unit to deflect laterally during the heat-curving process will not cause the unit to overturn.

When curved in the horizontal position, the unit shall be properly supported to obtain a uniform curvature. The bending stress in the flanges attributable to the dead weight of the girder shall not exceed the allowable design stress. When the unit is positioned horizontally for heating, safety catch blocks shall be maintained at the midlength of the unit within 2 inches of the flanges at all times during the heating process.

Any method of handling, supporting, or loading that causes the unit to distort permanently (yield without the application of heat) will result in rejection of the unit.

- e. **Artificial cooling:** Quenching will not be permitted. Cooling with dry compressed air will be permitted after the steel has naturally cooled to 600 degrees F.
- f. **Measurement of curvature:** Prior to final acceptance of horizontal curvature, welding and heating operations shall have been completed and the unit cooled to a uniform temperature.
- (c) **Camber:** Rolled beams and plate girders shall be cambered in the amount indicated on the plans. Camber shall approximate a parabolic curve. Camber for rolled beams shall be obtained by heat-cambering methods. For plate girders, the web shall be cut to the prescribed camber with a suitable allowance for shrinkage attributable to cutting, welding, and heat curving.

Tolerance for the specified camber of welded beams or girders before erection shall not exceed the greater of (A) or (B).

$$(A) + 1/4 \text{ inch} \times \frac{\text{Feet of Test Length}}{10} \quad (\text{Not to exceed } 3/4 \text{ inch})$$

$$(B) + 1/8 \text{ inch} \times \frac{\text{Feet from nearest end}}{10}$$

Tolerance for the specified camber of rolled beams as measured at midlength shall be:

$$+ 1/8 \text{ inch} \times \frac{\text{Feet of Length}}{10}$$

Camber shall be measured with the beam or girder laying on its side on a flat horizontal surface.

- (d) **Bolt Holes:** Bolt holes shall be punched, drilled, or reamed as specified herein. Holes shall not be flame cut or electrode cut.

Finished holes shall be 1/16 inch larger than the nominal bolt size. Oversized holes will be permitted only with the permission of the Engineer or in accordance with the requirements of Section 407.06(a). Finished holes shall be within 1/16 inch of the plan gage and match-mating holes, with no offset greater than 1/16 inch. Holes varying more than 1/16 inch from the plan gage will be rejected.

Burrs shall be removed from holes.

1. **Punched holes:** The diameter of the die shall not exceed the diameter of the punch by more than 1/16 inch.

Holes shall not be punched in structural carbon steel conforming to the requirements of ASTM A 709, Grade 36, thicker than 3/4 inch, or in high-strength structural steel conforming to the requirements of ASTM A 709, Grade 50W, or higher, thicker than 5/8 inch. When these thicknesses are exceeded, holes shall be subdrilled and reamed or drilled full size.

Holes may be punched full size (1/16 inch larger than bolts) in secondary units or members and their connecting plates or angles. Holes shall be clean cut, without torn or ragged edges. Structural members identified in Section 407.04(k)1 or in the plans, special provisions, or other contract documents as main (primary) members or units shall not be punched full size.

Subpunched holes that are to be reamed shall be 3/16 inch smaller in diameter than the nominal bolt size. The location offset between subpunched holes assembled for reaming shall be not more than 1/8 inch.

2. **Reamed and drilled holes:** Holes shall be subdrilled and reamed to 1/16 inch larger than bolts. If numerically controlled drilling equipment is used, the Contractor may be required by means of check assemblies to demonstrate that this procedure consistently produces holes that conform to the dimensions shown on the plans. Connections shall conform to the requirements of this section. Shop assembly for numerically controlled drilled connections shall conform to the requirements of AASHTO's *Standard Specifications for Highway Bridges*.

- (e) **Cut Edges of Plates and Shapes:** Cut edges shall have their corners rounded to a radius of 1/16 inch.

Sheared edges of plates more than 5/8 inch in thickness shall be planed to a depth of 1/4 inch.

Structural steel may be flame cut provided a smooth surface free from cracks and notches is achieved and that an accurate profile is achieved by the use of a mechanical guide. Free-hand cutting shall be done only where approved by the Engineer.

Flame cutting in the field is prohibited.

- (f) **Facing of Bearing Surfaces:** The surface finish of bearing and base plates and other bearing surfaces that are to come in contact with each other or with concrete shall conform to the following surface roughness requirements as defined in ANSI B46.1:

	Roughness Height (microinches)
Steel slabs	2,000
Heavy plates in contact in shoes to be welded	1,000
Milled ends of compression units, stiffeners, and fillers	500
Bridge rollers and rockers	250
Pins and pin holes	125
Sliding bearings	125

- (g) **Bent Plates:** The radius of bends shall be such that the plate does not crack. The minimum bend radii, measured to the concave face of the metal, shall be as follows:

Thickness (t) (inches)				
Up to 1/2	Over 1/2 to 1	Over 1 to 1 1/2	Over 1 1/2 to 2 1/2	Over 2 1/2 to 4
$2t$	$2 \frac{1}{2}t$	$3t$	$3 \frac{1}{2}t$	$4t$

Low-alloy steel more than 1/2 inch in thickness may require hot bending for small radii. If a shorter radius is essential, the plates shall be bent hot at a temperature of not more than 1200 degrees F.

Before bending, the corners of the plate shall be rounded to a radius of 1/16 inch throughout the portion of the plate at which the bending is to occur.

- (h) **Annealing and Stress Relieving:** Structural units that are indicated on the plans, the specifications, or other contract documents to be annealed or normalized shall have finished machining, boring, and straightening done after heat treatment. Temperatures shall be maintained uniformly throughout the furnace during heating and cooling cycles so that the temperature of any two points on the unit will not differ at any time by more than 100 degrees F.

A record of each furnace charge shall identify the pieces in the charge and show the temperatures and schedule actually used. Proper instruments, including recording pyrometers, shall be provided for determining the temperature of units in the furnace at any time. The records of the treatment operation shall be available for inspection by the Engineer.

- (i) **Pins and Rollers:** Pins and rollers shall be forged or fabricated of cold-finished carbon steel shafting. In pins larger than 9 inches in diameter, a hole at least 2 inches in diameter shall be

bored full length along the axis. Threads for pins shall conform to the American National Coarse Thread Series, Class 2, free fit, except that pin ends having a diameter of 1 3/8 inches or more shall be threaded six threads to the inch.

Pinholes shall be bored at right angles with the axis of the unit. Boring holes in fabricated units shall be performed after welding is completed. The diameter of the pinhole 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.

- (j) **Stud Shear Connectors:** The diameter of the connectors shall be 7/8 inch, and the length shall be at least 4 inches. Heads shall project at least 2 inches above the plane of the bottom of the deck slab and shall be 3 inches below the plane of the top of the deck slab. In determining the required length, the computed dead-load deflection, vertical curve correction, and actual (measured) camber of the fabricated beam shall be taken into consideration. Studs 3/4 inch in diameter may be substituted for 7/8-inch studs, or vice versa, by making an adjustment in the pitch proportionally to the cross-sectional area of the studs with a spacing of not more than 24 inches. Studs shall be adjusted as necessary to provide clearance for bolts in bolted splices. When prestressed deck panels for cast-in-place concrete deck slabs are to be used, the edge distance of studs shall be adjusted to provide the necessary support areas for ends of the deck panels. Studs shall be end welded automatically or semi-automatically to the steel beams. The method and equipment used shall be as recommended by the manufacturer of the studs and shall be approved by the Engineer. Studs shall be field welded after structural steel is erected and metal decking or other walking or working surface is in place; however, structural steel with shop-applied studs may be erected provided erection is performed in accordance with the requirements of Section 107.17.
- (k) **Shop Assembly:** Assembly shall be in accordance with the following:
1. **Holes for field connections and field splices** in the following main units shall be drilled with units assembled or numerically controlled drilled. Holes shall not be punched full size in the following main units or their connecting plates and angles:
 - a. Girders and rolled beams.
 - b. Trusses, arches, and towers.
 - c. Bent and rigid frames.
 - d. Diaphragms, crossframes, or bracing attached to straight steel box girders or attached to curved rolled beams, curved I girders, or curved steel box girders.
 - e. Any member designated on the plans or in other contract documents as "fracture critical."
 - f. Any other main (primary) member(s) or unit(s) identified as such in the plans, special provisions, or other contract documents.
 2. **Holes for floor-beam and stringer-end connections** shall be subpunched or subdrilled and reamed to a template or reamed while assembled. Templates used for connections on like parts shall be located so that the parts are identical and require no match marking.

3. **Surfaces of metal in contact** shall be cleaned before assembly. Parts shall be drawn together and securely clamped before drilling or reaming. Units shall be free from twists, bends, or other deformation.
 4. **Drift pins** may be used only to bring parts into position. If any holes must be enlarged to admit bolts, the hole shall be reamed as permitted in these specifications.
 5. **Connecting parts assembled in the shop** for the purpose of reaming holes shall be match marked. Miscellaneous parts that are not completely bolted in the shop shall be secured by partial bolting to prevent loss or damage in shipment and handling.
- (l) **Inspection:** The Contractor shall perform quality control inspection, including, but not limited to, visual inspection and nondestructive testing. Visual inspection shall be performed in accordance with the requirements of VTM-33 by inspectors qualified in accordance with the requirements of ANSI/AASHTO/AWS Bridge Welding Code D1.5 or AWS Structural Welding Code D1.1, as applicable. Radiographic and magnetic particle testing shall be performed in accordance with the requirements of VTM-29 and VTM-31, respectively. Ultrasonic testing, when specified, shall be performed in accordance with the requirements of VTM-30. Railroad structures and fracture-critical units shall be given radiographic and ultrasonic inspections in accordance with the requirements of VTM-44.

The Engineer reserves the right to perform quality assurance inspection. The Contractor shall provide and furnish a Type III field office in accordance with the requirements of Section 514 for use in the Engineer's inspection of material and workmanship within the shop. In addition to the requirements specified therein, the Contractor shall provide telephone service by a direct access line, a telephone, and maintenance thereof. Costs for installation of the direct access line, the telephone, maintenance, and local service shall be borne by the Contractor. The cost for long-distance will be borne by the Department. The Engineer shall be allowed free access to the necessary parts of the work. One reinspection of corrective action taken on defective material or fabrication will be performed by the Department without cost to the Contractor; the cost of further reinspections shall be borne by the Contractor. The cost of any retests made necessary by the replacement of rejected welds shall be borne by the Contractor. When requested, the Contractor shall provide working space for radiographic examination of welds and shall make such space available for at least 6 hours per inspection visit.

407.05—Handling, Storing, and Shipping Materials

Materials and units shall be placed at least 4 inches above the ground on platforms, skids, or other supports. They shall be supported in such a manner that they will not be overstressed or become deformed or otherwise damaged. High-strength bolts, nuts, and washers shall be stored in identifiable original containers in protective storage subject to the approval of the Engineer. Materials shall be kept free from dirt, grease, and other foreign materials; protected from corrosion; and properly drained.

- (a) **Material Furnished by Others:** If the Contract is for erection only, the Contractor shall check the material delivered against the shipping lists and report promptly in writing any shortage or damage. The Contractor shall be responsible for the loss of any material in his care or for any damage incurred after the shipment is received.

- (b) **Marking and Shipping:** Each unit shall be identified with an erection mark, and an erection diagram shall be furnished.

The Contractor shall furnish as many copies of shipping statements and erection diagrams as the Engineer may require. The weight of each unit shall be shown on the statements. Units having a weight more than 3 tons shall have the weight marked thereon. Structural units shall be loaded on trucks or cars in such a manner that they may be transported and unloaded at their destination without being excessively stressed, deformed, or damaged. Main structural units shall be supported at their bearings or at such other supports as may be approved or directed by the Engineer.

Bolts of one length and diameter and loose nuts or washers of each size shall be packed separately. Pins; small parts; and packages of bolts, washers, and nuts shall be shipped in boxes, crates, kegs, or barrels. A list and description of the contained material shall be plainly marked on the outside of each shipping container.

407.06—Erection Procedures

If the Contract is for erection only, the Contractor will receive the materials entering into the finished structure, free of charges, at the place designated and loaded or unloaded as specified. The Contractor shall promptly unload material he is required to unload and shall be responsible for demurrage charges.

Before starting the work of erection, the Contractor shall fully inform the Engineer as to the method proposed to be followed and the amount and character of equipment to be used, which shall be subject to approval. No work shall be done until such approval has been obtained. The approval of the Engineer shall not relieve the Contractor of the responsibility for ensuring the safety of his methods or equipment or performing the work in accordance with the plans and these specifications.

When new steel beams are connected to existing steel beams, the Contractor shall temporarily connect the diaphragms to the beams, in a manner to allow for the deflection of the new beams after placement of the deck slab concrete. After the deck slab concrete has cured, the Contractor shall connect the diaphragms as shown on the plans.

The Contractor shall erect steel, remove temporary construction, and perform all work required to complete the structure(s) or specified in the Contract, including removing the old structure(s), if specified, in accordance with the requirements of the plans and the specifications.

- (a) **Field Welding:** When erection includes field welding, field welding and inspection shall be performed in accordance with the requirements of Section 407.04.
- (b) **Misfits Field Assembly:** Correction of misfits will be considered a legitimate part of erection provided corrective work is necessary on not more than 10 percent of the holes in a continuous group of 10 or more holes or 10-percent of the number of individual pieces with fewer than 10 holes.

Drift pins may be used only to bring parts into position. Misaligned holes shall be corrected, where allowed by the Engineer, by reaming. However, no hole shall be elongated in any separate part to more than 1/8 inch larger than the nominal bolt size when a reamer not

more than 1/16 inch larger than the nominal bolt size is used. The misalignment of holes before reaming shall not be more than 1/8 inch.

Necessary work exceeding these figures will be considered caused by shop errors and will be reported to the responsible party. Damage resulting from handling or transportation shall be reported to the Engineer.

When the Contract provides for complete fabrication and erection, the Contractor shall be responsible for misfits and errors and shall make the necessary corrections or replacements. When the Contract is for erection only, the Engineer, with the cooperation of the Contractor, will keep a record of labor and material used and the Contractor shall render within 30 days an itemized bill approved by the Engineer.

(c) **Assembly of Structural Connections Using High-Strength Bolts:** Field connections shall be made with high-strength bolts 7/8 inch in diameter fabricated in accordance with ASTM A 325 unless otherwise specified. Consideration will be given to the substitution of adequately designed welded connections if requested in writing by the Contractor.

1. **Bolts, nuts, and washers:** Bolts, nuts, and washers shall conform to the requirements of Section 226 and shall each be from one manufacturer on any one structure unless otherwise approved by the Engineer. In addition, each bolt, nut, and washer combination, when installed, shall be from the same rotational-capacity lot. Prior to installation, the Contractor shall perform a field rotational-capacity test on two nut, bolt, and washer assemblies for each diameter and length in accordance with the requirements of Section 226.02(h)3. Bolts fabricated in accordance with ASTM A 490 and galvanized bolts fabricated in accordance with ASTM A 325 shall not be reused. Retightening previously tightened bolts, which may have been loosened by the tightening of adjacent bolts, shall not be considered a reuse. Other bolts may be reused only if approved by the Engineer. Threads of plain (uncoated) bolts shall be oily to the touch when installed. Galvanized nuts shall be lubricated containing a visible dye. Threads of weathered or rusted bolts shall be cleaned of loose rust and debris and relubricated. Lubricant shall be as recommended by the fastener manufacturer.
2. **Bolted parts:** Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material.

Before assembly, connecting surfaces, including areas adjacent to the washers, shall be free from scale except tight mill scale and shall be free of burrs, dirt, and other foreign material that would prevent solid seating of the parts. Surfaces for bolted splices in main units fabricated from weathering steel and joint surfaces for other connections, when required on the plans, shall be blast cleaned in accordance with the requirements of Section 411.04(a)5. The minimum area to be blast cleaned shall be 12 inches beyond the outermost row of bolts in the flanges and web and shall include the entire contact surfaces of the splice plates and filler plates. Contact surfaces shall be free from dirt, loose scale, burrs, oil, lacquer, and rust inhibitor.

3. **Installation:** Only as many fasteners as are anticipated to be installed and tightened during a work shift shall be taken from protected storage. Fasteners not used shall be returned to protected storage at the end of the shift. Bolts shall be installed with a hardened washer under the nut or bolt head, whichever is the element turned in tightening.

TABLE IV-3
Bolt Tension

Bolt Size	Required Min. Bolt Tension (lb)	
	ASTM A 325 Bolts	ASTM A 490 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

When bolts fabricated in accordance with ASTM A 490 are used with steel having yield points less than 40 kips per square inch, hardened washers shall be installed under the nut and bolt head.

An approved tension-indicating device shall be at all job sites where high-strength fasteners are being installed and tightened. Bolt tensioning devices and complete bolt assemblies shall be tested with this device at the start of construction and as required for the installation procedure. The calibrating device shall be capable of indicating actual bolt tension within a tolerance of 2 percent. The manufacturer or an approved testing agency shall have checked the device for the accuracy specified herein within the previous 12 months. When turn-of-nut or direct tension indicators are used, a representative sample of at least three complete bolt assemblies of each diameter, length, and grade shall be tested. For short grip bolts, direct tension indicators with solid plates may be used to perform the required testing. However, the direct tension indicator shall be checked with a longer grip bolt in the approved tension-indicating device prior to testing with short grip bolts.

A flat washer may be used when the surface adjacent to the bolt head or nut does not have a slope of more than 1:20 with respect to a plane normal to the bolt axis. Where an outer face of the bolted parts has a slope of more than 1:20 with respect to a plane normal to the bolt axis, a smooth beveled washer shall be used to compensate for the lack of parallelism. The threaded ends of bolts shall be placed on the inside, where practicable, for protection from weather.

The length of bolts shall be such that the point of the bolt will be flush with or outside the face of the nut when completely installed without overtensioning the bolt.

Fasteners shall be tightened to provide, when all fasteners in the connection are tight, at least the minimum bolt tensions shown in Table IV-3 for the size of the fastener used. Tightening shall be performed by the turn-of-nut method or by the use of a direct tension indicator using a load indicator washer. Power wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately 10 seconds.

TABLE IV-4
Nut Rotation From Snug Tight Condition

Bolt Length Measured From Underside of Head to Extreme End of Point	Disposition of Outer Faces of Bolted Parts		
	Both Faces Normal to Bolt axis	One Face Normal to Bolt Axis and Other Face Sloped Not More Than 1:20 (Bevel Washer Not Used)	Both Faces Sloped Not More Than 1:20 From Normal to Bolt Axis (Bevel Washers Not Used)
Up to and including 4 diameters	1/3 turn	1/2 turn	2/3 turn
More than 4 but not more than 8 diameters	1/2 turn	2/3 turn	5/6 turn
More than 8 but not more than 12 diameters	2/3 turn	5/6 turn	1 turn

If required because of bolt-entering and wrench-operation clearances, tightening by either procedure may be done by turning the bolt while the nut is prevented from rotating provided both the head and nut bear against surfaces having slopes not greater than 1:20.

The required minimum bolt tension is equal to 70 percent of specified minimum tensile strengths of bolts rounded to the nearest kip as specified in ASTM A 325 and ASTM A 490.

Snug tight is defined as the tightness attained when a power wrench begins to impact solidly or when the bolts are firmly hand tightened with a spud wrench such that the complete area of the connecting surfaces are brought into firm contact with each other. Snug tightening shall progress systematically from the most rigid part of the connection to the free edges, and then the bolts of the connection shall be retightened in a similar systematic manner as necessary until all bolts are simultaneously snug tight and the connection is fully compacted.

- a. **Turn-of-nut tightening:** When the turn-of-nut method for tightening high-strength bolts is used, bolts shall be installed in all holes and tightened to a snug tight condition to ensure that all parts of the joint are brought into contact with each other. Bolts shall be given a suitable match-mark and tightened additionally by the applicable amount of nut rotation specified in Table IV-4, progressing systematically from the most rigid part of the joint to its free edges. During this operation, there shall be no rotation of the part not turned by the wrench. Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. For bolts installed by +1/2 turn and less, the tolerance is minus 0 plus 30 degrees; for bolts installed by 2/3 turn and more, the tolerance is minus 0 plus 45 degrees.
- b. **Direct tension indicators:** When direct tension indicators are used, installation shall be in accordance with the requirements of Section 407.06(b)3. However, the indicator washer shall not be considered a substitute for the required hardened washer under the turned element but may be considered a substitute for the hard-

ened washer required under the unturned element when bolts conforming to the requirements of ASTM A 490 are used with steel conforming to the requirements of ASTM A 709, Grade 36. Direct tension-indicator washers shall not be painted or coated with any epoxy or similar material prior to installation. The normal installation shall consist of the load indicator being placed under the unturned bolt head or unturned nut. However, if conditions required installation under the turned bolt portion, a hardened flat washer or nut face washer shall be fitted against the tension-indicating protrusions. Tension-indicating washers shall not be substituted for the hardened washers required with short-slotted or oversized holes but may be used in conjunction with them.

The initial installation shall be to a snug tight condition, after which final tightening shall be performed by progressing systematically from the most rigid part of the connection to its free edges until the tension indicators on all bolts are closed to at least the required gap.

The required gap shall be 0.015 inch or less between the indicator and the underside of the bolt head or nut when no washer is used with the indicator. If a hardened flat washer is incorporated, the required gap shall be 0.010 inch or less between the indicator and the hardened flat washer. If the indication gap is closed completely, additional tightening shall not be continued.

4. **Inspection:** The Engineer will observe the installation and tightening of bolts to determine that the selected tightening procedure is properly used and will determine that all bolts are tightened.

The Contractor in the presence of the Engineer shall use an inspection wrench to inspect the tightening of bolts. No fewer than three typical bolts from the lot to be installed having a length representative of bolts used in the structure shall be placed individually in a calibration device capable of indicating bolt tension at least once each working day. There shall be a washer under the part turned in tightening each bolt if washers are so used on the structure. If no washer is used, the material abutting the part turned shall be of the same specification as that used on the structure.

When the inspection wrench is a torque wrench, each calibration test bolt shall be tightened in the calibration device to the minimum tension specified for its size in Table IV-3. The inspection wrench shall then be applied to the tightened bolt, and the torque necessary to turn the nut or bolt head 5 degrees (approximately 1 inch at 12-inch radius) in the tightening direction shall be determined. The average torque measured in the tests of three bolts shall be taken as the job-inspection torque. The torque wrench shall be a dial torque wrench and checked for accuracy within 1 year by the manufacturer or an approved testing agency.

When the inspection wrench is a power wrench, it shall be adjusted so that it will tighten each calibration test bolt to a tension of at least 5 but not more than 10 percent greater than the minimum tension specified for its size in Table IV-3. This setting of the wrench shall be taken as the job-inspection torque.

Bolts that have been tightened in the structure shall be inspected in the presence of the Engineer by applying, in the tightening direction, the inspection wrench and its job-inspection torque to 10 percent of the bolts but not fewer than two bolts selected at ran-

dom in each connection. If no nut or bolt head is turned by this application of the job-inspection torque, the connection will be accepted as properly tightened. If any nut or bolt head is turned by the application of the job-inspection torque, this torque shall be applied to all bolts in the connection. Bolts whose nut or head is turned by the job-inspection torque shall be tightened and reinspected or all the bolts in the connection may be retightened and the connection resubmitted for the specified inspection.

Inspection of installations using tension-indicating washers will normally be accomplished by checking the residual gap with a metal feeler gage. Installations will be considered satisfactory if the average gap per bolt installation does not exceed 0.012 inch for a tension-indicating washer installed under the bolt head or 0.010 inch for a tension-indicating washer installed in conjunction with a hardened, flat washer or if the gap has been reduced to zero at any point around the indicator.

The Engineer may verify by calibrated torque wrench that the work conforms to the requirements of Table IV-3 regardless of the method of installation.

- (d) **Abutting Joints:** Abutting joints in compression units and in tension units where so shown on the plans shall be faced and brought to an even bearing. Where joints are not faced, the opening shall be not more than 3/8 inch.
- (e) **Alignment at Bearings and Transverse Connections:** Beam ends, bearing stiffeners, and webs of girders and rolled structural shapes and other beam sections shall be vertical.

Diaphragms or cross struts composed of channel sections not attached to bearing stiffeners may be fitted with the planes of their webs perpendicular to the planes of the flanges of longitudinal beams on gradients provided the channel flanges are turned to the downgrade side where practicable.

Rolled beams and plate girders and their bearing assemblies shall be fabricated so that their bottom bearing surfaces lie in horizontal planes when in their erected positions. Steel plates for use with flexible bearing pads shall be beveled to conform to this requirement.

- (f) **Falsework:** Falsework shall be designed, constructed, and maintained for the loads that will rest upon it. The Contractor shall prepare and submit to the Engineer, for review, plans for falsework or for changes in an existing structure necessary for maintaining traffic. The Department's review of the Contractor's plans shall not relieve him of any responsibility.

The Contractor shall have a Professional Engineer holding a valid license to practice engineering in the Commonwealth of Virginia inspect the completed falsework assembly supporting a bridge superstructure prior to placing loads. The Professional Engineer shall provide a certification based upon visual inspection of the completed falsework assembly that the falsework assembly conforms to the approved working drawings. However, such certification shall not require an exhaustive inspection or testing or make the Professional Engineer liable for any deficiencies in workmanship or materials by the Contractor or for such conditions that cannot be ascertained from a visual inspection.

- (g) **Straightening Material in the Field:** Straightening plates and angles or other shapes shall be done by methods that will not produce fracture or damage. Metal shall not be heated unless permitted by the Engineer, in which case the heating shall not exceed 1200 degrees F

as measured by temperature-indicating crayons or other approved means. After heating, the metal shall be cooled naturally.

Following straightening of the shape, the surface of the metal shall be carefully inspected for evidence of fracture. If the damage was caused by the Contractor, the cost of inspection shall be borne by the Contractor.

- (h) **Assembling Steel:** Bearing surfaces that will be a permanent contact shall be cleaned before units are assembled.

Permanent bolts in splices of butt joints of compression units and permanent bolts in railings shall not be tightened until blocking and falsework have been removed. Immediately after erection, splices and field connections shall have at least one-half of the holes filled with bolts or cylindrical erection pins, of which one-half shall be bolts. Splices and connections carrying traffic during erection shall have holes filled with high-strength bolts that have been torqued prior to opening to traffic.

Erection bolts shall be of the same nominal diameter as the high-strength bolts, and cylindrical erection pins shall be 1/32 inch larger.

- (i) **Finishing:** Unpainted weathering steel units shall be abrasive blast cleaned in the shop after fabrication. Abrasive blast cleaning shall conform to the requirements of SSPC-SP6/NACE No. 3, Commercial Blast Cleaning. Upon completion of erection and concrete work, the fascia of exterior beams and girders of unpainted weathering steel shall be cleaned in accordance with the requirements of Section 411.04(a)3.

Wherever a depressed area is formed whereby water can be trapped or held, such as the juncture between a beam or girder web and splice plate on a bottom flange, the area shall be completely sealed with polyurethane, or other approved sealant, conforming to the requirements of FS TT-S-00230C, Type II, Class A, prior to painting. When the sealant is used in conjunction with weathering steel, the sealant shall be integrally pigmented to a dark bronze color.

Weathering steel shall be cleaned and painted in accordance with the requirements of Section 411.

- (j) **Protective Coatings:** Non-stainless ferrous metal surfaces shall be cleaned and painted in accordance with the requirements of Section 411. Galvanizing shall conform to the requirements of Section 233.

When new steel beams are connected to existing steel beams, the Contractor shall temporarily connect the diaphragms to the beams in a manner to allow for the deflection of the new beams after placement of the deck slab concrete. After the deck slab concrete has cured, the Contractor shall connect the diaphragms as shown on the plans

407.07—Measurement and Payment

Structural steel, including beams, girders, and miscellaneous steel, will be paid for at the contract lump sum price or, when specified, in pounds of metal in the fabricated structure, including bolts shipped, as weighed on a shop scale. However, any weight more than 1.5 percent above the computed

weight for the entire structure will not be included for payment. The weight of erection bolts, field paint, boxes, crates, and other containers used for packing and materials used for supporting units during transport will not be included.

In contracts having a pay item for structural steel, structural steel components, including shear connectors, bearing plates, bearing assemblies and pads, anchorages, expansion joints, bolts, and pedestals, whether embedded in concrete or not, and other metals or materials shall be included in the price for structural steel unless paid for as a separate pay item(s). Prices for structural steel shall include furnishing, fabricating, galvanizing, transporting, erecting, and field painting.

If specified in the Contract or permitted by the Engineer, weights may be computed, in which case the computations shall be on the following basis:

- (a) The unit weights of metal shall be as follows:

	Lb/Cu Ft
Aluminum, cast or wrought	173.0
Brass	536.0
Bronze, cast	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, cast, copper-bearing, carbon, silicon, nickel, and stainless	490.0
Zinc	450.0

- (b) The weight of rolled shapes and plates up to and including 36 inches in width shall be computed on the basis of their nominal weights and dimensions as shown on the approved working drawings, deducting for copes, cuts, and open holes except bolt holes.

The allowed percentage of overrun in weight specified in AASHTO M 160 shall be added to the nominal weights of plates more than 36 inches in width.

- (c) The weight of high-strength bolt heads, nuts, and washers shall be included on the basis of the following:

Diameter (in)	Weight Per 100 (lb)
1/2	18
5/8	31
3/4	52
7/8	78
1	111
1 1/8	152
1 1/4	206

The weight of high-strength bolts includes the head, the nut, the projection of the bolt through the nut, and one flat washer per bolt.

- (d) The weight of castings shall be computed from the dimensions shown on the approved working drawings, deducting for open holes. To this weight shall be added 10 percent for fillets and overrun.
- (e) As an allowance for shop paint, 0.4 percent shall be added to the total computed weight of metal.
- (f) The weight of metal railing shall be included unless it is a pay item.
- (g) Steel grid flooring will be measured and paid for in accordance with the requirements of Section 409.
- (h) The weight of steel or brass shims required shall be included.

Fabrication of structural steel, when a pay item, shall include fabricating; cleaning and shop painting structural units; bolts; nuts; washers; and transporting and storing units at the designated location.

Erection of structural steel, when a pay item, shall include equipment and incidentals required to transport units from their designated storage location to the erection site, unloading and storing, erecting, cleaning, and field painting.

The cost of testing unit(s) required by the specifications shall be included in the price for the structural unit(s).

Payment will be made under:

Pay Item	Pay Unit
Structural steel (Type)	Lump sum or Pound
Fabrication of structural steel (Type)	Lump sum
Erection of structural steel (Type)	Lump sum

SECTION 408—BEARING DEVICES AND ANCHORS

408.01—Description

This work shall consist of furnishing and installing bearing plates, pads, rockers, expansion devices, anchors, or other devices used in conjunction with bearings or anchorages at superstructure supports in accordance with these specifications and in conformity with the plans or as established by the Engineer.

408.02—Materials and Fabrication

- (a) **Bearing material and bearing pads** shall conform to the requirements of Section 237 and those specified herein.

- (b) **Metal plates, shapes, bolts, and bars** shall be of structural steel conforming to the requirements of Section 226 and those specified herein.
- (c) **Metal parts** shall be fabricated in accordance with the requirements of Section 407.
- (d) **Painting** shall conform to the requirements of Section 411.
- (e) **Galvanizing** shall be performed in accordance with the requirements of Section 233.

408.03—Procedures

- (a) **High-Load Multi-Rotational Bearings:** High-load multi-rotational bearings including sole and masonry plates shall be any type shown on the plans and shall be provided by only one manufacturer.

Other high-load multi-rotational bearing designs may be acceptable provided they are supported by engineering analysis, engineering calculations, data and evidence of acceptable service life for the proposed materials, tests, and proven experience for the proposed bearing designs acceptable to the Engineer for the loads, forces, movements, and service conditions specified. Engineering analysis shall be performed by a registered Professional Engineer with a current license in the Commonwealth.

Notations: All dimensions are in inches:

C	= Clearance between pot and surface immediately above or below it.
Dp	= Diameter of elastomeric disc, inside diameter of pot bearing.
Ds	= Projected diameter of loaded spherical segment.
G	= Depth of pot bearing cavity.
k	= Depth of chamfer on pot bearing piston.
Fy	= Yield strength of steel in ksi.
Lh	= Horizontal design load on bearing in kips.
Lv	= Vertical design load on bearing in kips.
ϑ	= ArcTan (Lh/Lv min)
Rb	= Minimum design rotation requirement of bearing in radians.
Rc	= Maximum construction tolerance rotation in radians.
Rs	= Minimum design rotation requirement of structure in radians.
Rmax	= Maximum radius to prevent unseating of spherical surfaces.
S	= Side of a square pot bearing plate.
t	= Thickness of elastomeric disc.
w	= Piston face width, pot bearing.
OD	= Outside diameter of a round pot.

1. **Design:** High-load multi-rotational bearings shall be designed to accommodate the loads, forces, and movements specified in the bearing schedule. Particular care shall be taken to ensure that all components of the bearings provide adequate capacity for the horizontal loads and forces specified.

Maximum design stresses for bearing components shall not exceed the allowable design stresses of the applicable issue of the AASHTO *Standard Specifications for Highway Bridges* and the applicable sections of these specifications.

Minimum rotation capacity, R_b , shall be the sum of $R_c + R_s$. R_c equals 0.02 radians. R_s equals the larger of 0.01 radian or the actual design rotations.

The minimum horizontal bearing design capacity for fixed and guided expansion bearing types shall be 10 percent of the vertical capacity or as specified in the plans. The minimum horizontal bearing design for non-guided expansion bearing types shall be equal to the frictional resistance of bearing slide surfaces or as specified in the plans.

Expansion bearings shall be designed for additional total movement capacity in each direction specified under "Design Movement" in the "Bearing Schedule." The additional total movement capacity shall be 10 percent of the design movement or 1 inch, whichever is greater. Spacing between the guides of the bearing does not require this additional movement capacity.

Bearings shall be designed so that rotational and sliding elements can be replaced with a minimum of jacking movement not greater than 1 inch.

2. Rotational elements—Pot bearings:

- a. **Pot:** Pot inside diameter, D_p , shall be the same as that of the elastomeric disc.

Depth of pot cavity, G , shall be equal to or greater than:

$$[(D_p/2) \times (R_s + R_c)] + 0.1 \text{ inch} + k + t + w$$

where:

k = for flat sealing

k = 1.7 x the ring cross-section diameter for round sealing rings where rings sit 100 percent in the chamfer

k = 1.2 x the ring cross-section diameter for round sealing rings where rings sit half recessed in the elastomeric disc and half in the piston chamfer. The details for the k dimension are provided in the plans.

Section thickness of the pot beneath the elastomer shall be a minimum of 3/4 inch or $D_p \times 0.06$ for bearings directly on concrete and 1/2 inch or $D_p \times 0.045$ for bearings directly on steel masonry plates.

Minimum outer plan dimensions of pots shall be determined by analyzing horizontal loads, internal elastomer pressure, and piston force due to friction in shear, bending, and tension, but the wall thickness shall in no case be less than the greater of 3/4 inch, $1.02 \times L_v / (D_p \times F_y)$ or the square root of $(40 \times L_h \times R_b / F_y)$.

- b. **Elastomeric disc:** Thickness of elastomeric disc, t , shall be equal to or greater than $R_b \times D_p / 0.3$.

Area of elastomeric disc shall be designed for an average stress of 3,500 pounds per square inch.

When using flat sealing rings, the upper edge of the disc shall be recessed to receive the rings so that they sit flush with the upper surface of the elastomeric disc.

The disc shall be lubricated with a silicone compound conforming to the requirements of MIL-S-8660 (Military Specification) or other approved equal. PTFE “shear-reducer discs” shall not be used with flat rings.

- c. **Piston:** Outside diameter of piston shall be $D_p - 0.04$ inch. Piston thickness shall be adequate to resist the loads imposed on it but shall not be less than $0.06 \times D_p$.

Piston thickness shall be adequate to provide clearance, C , between the top of the pot and the surface immediately above it as follows:

(1) $C = R_b \times (0.7 \times S) + 0.12$ inch for pots square in plan.

(2) $C = R_b \times (OD / 2) + 0.12$ inch for pots round in plan.

Piston face width, w , is the part of the edge of the piston that contacts the pot wall. When designing pistons for horizontal forces, w shall not be less than the greater of $0.03 \times D_p$, 1/4 inch or $1.59 \times L_h / (D_p \times F_y)$.

Pistons for round seals shall have the lower corner chamfered at 45 degrees for a depth equal to 1.7 times the diameter of the seal where the seal is wholly within the piston thickness and 1.2 times the diameter where it extends into the elastomer for half its diameter.

- d. **Elastomer sealing rings:**

Flat sealing rings shall conform to the following requirements:

- (1) Width shall be equal to or greater than the larger of $0.02 \times D_p$ or 1/4 inch but shall not exceed 3/4 inch.
- (2) Minimum thickness of each sealing ring shall be equal to or greater than 0.2 times the width.
- (3) Three rings shall be used. Rings shall be a snug fit to the pot wall and have their ends cut at 45 degrees to the vertical and to the tangent of the circumference with a maximum gap of 0.050 inch when installed. Ring gaps shall be staggered equally around the circumference of pots. Rings shall be free of nicks, burrs, or sharp edges.

Round sealing rings shall conform to the following requirements:

- (1) Rings shall be rolled into a circle from rod and brazed or welded. They shall fit the pot snugly so that they are in full contact with the pot wall when installed.
- (2) Ring diameters shall be equal to or greater than the larger of $0.0175 \times D_p$ or 5/32 inch.

3. **Rotational elements—Spherical bearings with PTFE/stainless steel surfaces:**

- a. **Rotational elements—Spherical concave surfaces—PTFE:** The spherical radius shall be determined such that the resulting geometry of the bearing is capable of withstanding the greatest ratio of horizontal load to vertical load under all loading conditions to prevent unseating the concave element. If required during construction, mechanical safety restraints shall be incorporated to prevent overturning of the bearing. Unseating of the curved surfaces relative to each other shall be prevented by transferring horizontal forces through specifically designed restraints or by control of the radius. Acceptable radius control is given when $R_{max} = D_s/[2 \times \sin(\theta + R_c + R_s)]$. Calculations showing the determination of the radius shall be submitted for approval.

The projected area of the PTFE shall be designed for the following maximum average working stress:

- | | |
|---|----------|
| (1) Unconfined, unfilled sheet PTFE: | 2.5 ksi. |
| (2) Unconfined, filled sheet PTFE: | 4.5 ksi. |
| (3) Confined sheet PTFE: | 4.5 ksi. |
| (4) Woven PTFE over a metallic substrate: | 4.5 ksi. |
| (5) Reinforced, woven PTFE over a metallic substrate: | 5.5 ksi. |

The concave shall face down whenever possible.

Thickness of PTFE fabric in the compressed state shall be a minimum of 1/16 inch when measured in accordance with ASTM D 1777. Recessed sheet PTFE shall be at least 3/16-inch thick when the maximum dimension of the PTFE is less than or equal to 24 inches and 1/4 inch when the maximum dimension of the PTFE is greater than 24 inches. Woven fabric PTFE that is mechanically interlocked over a metallic substrate shall have a minimum thickness of 1/16 inch and a maximum thickness of 1/8 inch over the highest point of the substrate.

The minimum center thickness of the spherical surfaces shall be 3/4 inch.

Vertical clearance between rotating and non-rotating bearing parts shall be no less than 1/8 inch at maximum rotation.

- b. **Rotational elements—Spherical concave surfaces—Bronze:** The spherical radius shall be determined such that the resulting geometry of the bearing is capable of withstanding the greatest ratio of horizontal force to vertical load under all loading conditions to prevent unseating the concave element. If required, mechanical safety restraints shall be incorporated to prevent overturning of the bearing. Bearing rotation of $R_s + R_c$ radians shall be considered in the bearing design to prevent overturning or uplift of the bearing. Calculations showing the determination of the radius shall be submitted for approval.

The spherical element shall be made from the following or other approved bronze alloys:

- (1) Type 1: ASTM B 22, Alloy C90500
- (2) Type 2: ASTM B 22, Alloy C91100
- (3) Type 3: ASTM B 22, Alloy C86300

The maximum design compressive stress for the projected area shall be:

- Type 1: 2,000 pounds per square inch.
- Type 2: 2,500 pounds per square inch.
- Type 3: 8,000 pounds per square inch.

The bearing surfaces shall have lubricant recesses consisting of either concentric rings, with or without central circular recesses with a depth at least equal to the width of the rings, or recesses. The recesses or rings shall be arranged in a geometric pattern so that adjacent rows overlap in the direction of motion.

The entire area of all bearing surfaces that have a provision for relative motion shall be lubricated by means of the lubricant-filled recesses. The lubricant-filled areas shall comprise not less than 25 percent of the total bearing surface. The lubricating compound shall be integrally molded at high pressure and compressed into the rings or recesses and project not less than 0.010 inch above the surrounding bronze plate.

The minimum center thickness of the spherical surface shall be 3/4 inch.

- c. **Rotational elements—Spherical convex surfaces:** The convex element shall be designed for rotation, $R_b = R_c + R_s$.

The edge thickness shall be a minimum of 3/4 inch for bearings directly on concrete or 1/2 inch for bearings directly on steel masonry plates.

For PTFE/stainless and bronze/stainless rotational surfaces, the stainless surface shall conform to one of the following:

- (1) Cold-formed stainless steel sheet complying with the requirements of ASTM A 167 or A 240, Type 304, 0.060- to 0.090-inch thick, with a finish equal to or less than 20 micro-inch rms, connected to a structural steel substate by a continuous weld.
- (2) Solid stainless steel conforming to the requirements of ASTM A 240, Type 304 or 304L, with a finish equal to or less than a 20 micro-inch rms connected to a structural steel substate by a continuous weld.
- (3) Stainless steel weld overlay a minimum of 3/32 inch thick with a finish equal to or less than 20 micro-inch rms on a structural steel substrate.

If sheet PTFE is used for guided surfaces, it shall be pigmented.

For bronze/carbon steel sliding surfaces, the surface finish shall be not more than 125 micro-inches rms.

4. **Rotational elements—Disc bearings:** Thickness of the disc, t , shall be equal to or greater than $\Delta + [(R_s + R_c) \times D_d \times 0.5]/\epsilon \text{ max}$

where:

Δ = deflection due to total compressive load

$\epsilon \text{ max}$ = strain due to all effects except for long-term creep.

The instantaneous deflection of the disc under total load shall not exceed 10 percent of the thickness of the unstressed disc, and the additional deflection due to creep does not exceed 8 percent of the thickness of the unstressed disc. Deflection caused by rotation shall not exceed the lesser of the instantaneous deflection under total load or 10 percent of the thickness of the unstressed disc.

The disc shall be designed for an average stress of:

- (a) 3,700 pounds per square inch for Polyether Urethane Compound A.
- (b) 5,000 pounds per square inch for Polyether Urethane Compound B.

The section thickness of the plate beneath the disc shall be a minimum of 3/4 inch or $D_p \times 0.06$ for bearings on concrete and 1/2 inch or $D_p \times 0.045$ for bearings directly on steel masonry plates.

Vertical clearance between rotating and non-rotating bearing parts shall be no less than 1/8 inch at maximum rotation.

The urethane disc shall be held in place by a shear restriction mechanism that is designed to allow free rotation of the bearing. The mechanism shall be designed to withstand the design forces on the bearing without exceeding the allowable shear stress of $0.4 F_y$, bending stress of $0.55 F_y$, and bearing stress of $0.8 F_y$, not including shear resistance of the disc. The mechanism shall be connected to the bearing plates by welding, bolting, or machining out of the solid.

5. **Non-rotational bearing elements:**

- a. **PTFE sliding surfaces:** The PTFE surface shall be made from pure virgin PTFE resin satisfying the requirements of ASTM D 4547. It shall be fabricated as unfilled sheet, filled sheet, or fabric woven from PTFE and other fibers. Unfilled sheets shall be made from PTFE resin alone. Filled sheets shall be made from PTFE resin uniformly blended with glass fibers or other chemically inert filler. The maximum filler content shall be 15 percent. Sheet PTFE shall be a minimum of 1/8 inch thick, epoxy-bonded into a square-edge recess 1/16 inch deep.

Woven fiber PTFE shall be made from pure PTFE fibers. Reinforced woven fiber PTFE shall be made by interweaving high strength fibers, such as glass, with the PTFE in such a way that the reinforcing fibers do not appear on the sliding face of the finished fabric. Woven fiber PTFE in the free state shall be a minimum of

1/16 inch thick when measured in accordance with ASTM D 1777 and shall be epoxy-bonded and mechanically fastened to the substrate using a system that prevents migration of epoxy through the fabric. Edges, other than the selvage, shall be oversown or recessed so that no cut fabric edges are exposed.

PTFE sliding surfaces shall be designed for the following maximum stresses:

	Average Contact Stress (ksi)	Edge Contact Stress (ksi)
(1) Unconfined, Unfilled Sheet PTFE	2.5	3.0
(2) Unconfined, Filled Sheet PTFE	4.5	5.5
(3) Confined Sheet PTFE	4.5	5.5
(4) Woven PTFE Over a Metallic Substrate	4.5	5.5
(5) Reinforced Woven PTFE Over a Metallic Substrate	5.5	7.0

- b. **Stainless steel sliding surfaces:** The stainless surface shall cover the mating surface in all operating positions plus 1 inch in each direction of movement. This is to conform with the requirements of (a)1. herein. Sheet stainless steel shall be 16- to 13-gage thick and connected to the substrate by a continuous weld around the entire perimeter. The sheet shall be in full contact with the substrate. Stainless steel welded overlay shall be a minimum of 3/32-inch thick after welding, grinding and polishing and be produced using Type 309L electrodes. Stainless steel sliding surfaces shall, preferably, face down.
- c. **Guide bars and central guide keys:** Central guide keys may be made integral by machining from the solid. Where a separate key or guide bar is used, it shall be fitted in a keyway slot machined to give a press fit and bolted or welded to resist overturning.

Guide bars may be made integral by machining from the solid or fabricated from bars welded, bolted, and/or recessed at the manufacturer's option.

Guide bars and central guide keys shall be designed for specified horizontal forces, but not for less than 10 percent of the vertical capacity of the bearing. Bolted connections shall be designed in accordance with the applicable AASHTO Specifications. Frictional resistance of bearing slide surfaces shall be neglected when calculating horizontal load capacity.

The total clearance between the key/guide bars and guided members (both sides) shall be 1/16 inch maximum. Guided members must have their contact area within the guide bars in all operating positions. Guiding off the fixed base or any extensions of it where transverse rotation is anticipated shall be avoided.

- d. **Sole and masonry plates:** For masonry plates, the concrete bearing stress on the loaded area shall not exceed $0.3 f'_c$. When the supporting surface is wider on all sides than the loaded area, the allowable bearing stress on the loaded area may be increased by the square root of (A_2/A_1) , but not by more than 2. When the supporting surface is sloped or stepped, A_2 may be taken as the area of the lower

base of the largest frustrum of the right pyramid or cone contained wholly within the support and having for its upper base the loaded area A1 and having side slopes of 1 vertical to 2 horizontal.

Allowable bending stress in sole and masonry plates is $0.63 F_y$.

The minimum thickness of sole and masonry plates shall be $3/4$ inch.

When designing recesses in masonry plates for horizontal forces, the depth of the recess shall be designed assuming the contact area as one-third of the circumference and allowable compressive stress as $0.8 F_y$. Minimum recess depth shall be $3/16$ inch.

6. **PTFE on guiding surfaces:** PTFE on guiding surfaces, when they are used, shall be designed for stresses given in (a)5.a. herein:

PTFE, when used on guiding surfaces, shall be bonded to and recessed in their substrate. In addition, PTFE shall be at least $3/16$ inch thick and mechanically fastened by a minimum of two screws to the substrate. The centerline of the screws shall be located a distance equal to twice the nominal screw diameter from the end of the PTFE strip. The top of the screws shall be recessed a minimum of 50 percent of the amount of protrusion of the PTFE above the guiding surface.

Unfilled sheet PTFE used on guide bars shall contain an ultraviolet (U.V.) inhibitor/screen.

7. **Materials:** Steel, except stainless steel, steel for guide bars, and shear-restriction pins and sleeves, shall conform to the requirements of ASTM A 709, with a minimum yield stress of 36 ksi. Exposed steel surfaces shall be painted. Guide bars and shear-restriction devices shall be as specified by the manufacturer.

Elastomeric disc for pot bearings shall be a Shore A 50 durometer and the base polymer shall be either 100 percent virgin natural polyisoprene (natural rubber) or 100 percent virgin chloroprene (neoprene) having the following physical properties as determined by the applicable ASTM tests:

Property	Test Procedures	Natural Rubber	Neoprene
Tensile Strength, psi, min.	ASTM D 412	2250	2250
Elongation at Break, %, min.	ASTM D 412	450	400
Hardness, Durometer A	ASTM D 2240	50 ± 5	50 ± 5
Oven Aging, 70 hr/158°F for natural rubber, 70 hr/212°F for neoprene			
Tensile Strength, change, max. %	ASTM D 573	-25	-15
Elongation, change, max. %		-25	-40
Hardness, points change, max.		+10	+15
Compression Set, 22 hr/158°F for natural rubber, 22 hr/212°F for neoprene, max. %	ASTM D 395 Method B	25	35
Ozone Resistance, 20% strain 100°F ± 2°F, Mounting Procedure D 518, Method B 48 hr @ 25 pphm ozone by vol. 100 hr @ 100 pphm ozone by vol.	ASTM D 1149	No Cracks	-
Low-Temperature Test Brittleness @ -40°F	ASTM D 2137 Procedure B	No Failure	No Failure

PTFE sliding surfaces shall be virgin PTFE resin-filled or unfilled PTFE sheets or PTFE fabric, all made from virgin PTFE resin.

PTFE resin shall be virgin material, not reprocessed, conforming to the requirements of ASTM D 1457. Specific Gravity shall be 2.13 to 2.19. Melting point shall be 327 degrees C ± 10 degrees C. Filler material, when used, shall be milled glass fibers, carbon, or other inert filler materials.

Adhesive material shall be an epoxy resin conforming to the requirements of FS MMM-A-134, PEP film or equal, as approved by the Engineer.

Unfilled PTFE sheet shall be made of virgin PTFE resin and shall conform to the following requirements:

- (1) Tensile strength, 2,800 pounds per square inch minimum, ASTM D 1457.
- (2) Elongation, 200 percent minimum, ASTM D 1457.

Filled PTFE sheet shall be made from virgin PTFE resin uniformly blended with inert filler material and shall conform to the following:

Property	Test Procedures	15% Glass Fibers	25% Carbon
Tensile Strength, psi, min.	ASTM D 1457	2000	1300
Elongation, min. %	ASTM D 1457	150	75
Specific Gravity, min.	ASTM D 792	2.2	2.1
Melting Point	ASTM D 1457	327°C	±10°C

Fabric PTFE shall be made from virgin PTFE oriented multifilament and other fibers. The minimum thickness under the application of vertical load shall be:

- a. 1/16 inch up to 3,500 pounds per square inch load
- b. 3/64 inch from 3,500 pounds per square inch to 6,000 pounds per square inch load.

Where the PTFE is to be epoxy bonded, it shall be etched by an approved manufacturer by the sodium naphthalene or sodium ammonia etching process.

Stainless steel sliding surfaces shall conform to the requirements of ASTM A 167 or A 240, Type 304, with a surface finish 20 micro-inches rms or less. Welded stainless steel overlay shall be produced using Type 309L electrodes.

Sealing rings may be made only of metal and shall conform to the following:

- Flat brass rings, ASTM B 36, half hard.
- Round cross-section rings, FS QQB626, composition 22, half hard.

Bronze elements shall conform to the following:

- Type 1, ASTM B 22, Alloy C90500.
- Type 2, ASTM B 22, Alloy C91100.
- Type 3, ASTM B 22, Alloy C86300.

Solid lubricant shall consist of a combination of solids having nondeteriorating characteristics, as well as lubricating qualities, and shall be capable of withstanding long-term atmospheric exposure, de-icing materials, and water. The use of molybdenum disulfide and other ingredients that may promote electrolytic or chemical action between the bearing elements shall not be used. Shellac, tars and asphalts, and petroleum solvents may not be used as binders.

Socket head cap screws shall conform to the requirements of ASTM A 574, High Strength, 1960 Series.

Adhesive material for bonding PTFE to steel shall be an epoxy resin conforming to the requirements of FS MMA-A-134, FEP film or approval equal.

8. Construction:

- a. **Flatness of bearings:** The flatness of bearings after welding and fabrication shall be determined by the following method:

A precision straightedge longer than the nominal dimension to be measured shall be placed in contact with the surface to be measured or as parallel to it as possible.

An attempt shall be made to insert a feeler gage having a tolerance of plus or minus 0.001 inch under the straightedge. Since layering of feeler gages tends to degrade accuracy, the least number of blades shall be used.

Flatness is acceptable if the feeler does not pass under the straightedge.

Flatness tolerances are arranged in the following classes:

- (1) Class A , 0.0005 inch x nominal dimension.
- (2) Class B, 0.001 inch x nominal dimension.
- (3) Class C, 0.002 inch, x nominal dimension.

Nominal dimension shall be interpreted as the actual dimension of the plate, in inches, under the straightedge.

In determining flatness, the straightedge may be located in any position on the surface to be evaluated and not necessarily at 90 degrees to the edges.

- b. **Rotational elements—Pot bearings:** Pot bearings may, preferably, be made from a solid plate by machining or fabricated by welding a flame cut shape to a plate. Fabricated pots shall be manufactured in conformance with the AASHTO/AWS D1.5 Bridge Welding Code. The outside diameter of pots fitting into a machined recess shall be ± 0.015 inch. For pots not so recessed, the tolerance on plan dimensions shall be $+1/8$ inch, -0 inch. The inside diameter of pots shall be machined to a tolerance of ± 0.005 inch up to and including 20 inches and ± 0.007 inch over 20 inches. The tolerance on the depth of the pot cavity shall be $+0.01$ inch, -0 inch. The underside of pots shall be machined parallel to the inside to a Class A tolerance. Machined surfaces in contact with elastomer shall have a finish of 63 rms or better. Other machined surfaces shall have a finish of 125 rms or better.

Elastomeric disc tolerance shall be:

- (1) Diameters greater than 20 inches, $\pm 3/32$ inch.
- (2) Diameters less than or equal to 20 inches, $\pm 1/16$ inch.
- (3) Discs may be made from up to three pieces, but the thinnest piece shall not be less than $1/2$ inch.
- (4) Total thickness of all pieces shall be -0 inch $+1/8$ inch.

Piston tolerances shall be:

- (1) Diameter greater than 20 inches, ± 0.007 inch.
 - (2) Diameter less than 20 inches, ± 0.005 inch.
 - (3) Sliding side, Class A tolerance.
 - (4) Elastomer side, Class B tolerance.
 - (5) Piston flange thickness, $+1/8$ inch, $-1/32$ inch.
 - (6) Piston flange diameter, $+1/8$ inch, $-1/32$ inch.
- c. **Rotational elements—Spherical bearings:** Spherical bearing machined diameters shall be ± 0.015 inch. Convex radius dimensions shall be $+0.000$ inch -0.010 inch. Concave radius dimensions shall be $+0.010$ inch, -0.000 inch. Mating surfaces shall be as in Design section; external edges may be as cast or flame-cut. Lower surface of convex element shall be Class C tolerance. The tolerance on the overall thickness of concave or convex plates shall be ± 0.03 inch.
- d. **Non-rotational elements—All bearings:**

Masonry and distribution plate tolerances shall be:

- (1) Plan dimensions less than or equal to 30 inches, -0 inch $+3/16$ inch.
- (2) Plan dimensions over 30 inches, -0 inch $+1/4$ inch.
- (3) Thickness tolerance shall be -0.030 inch $+0.060$ inch.

Masonry plates used with pot or spherical bearings shall be Class C for the underside and Class A for the upperside tolerance.

PTFE sheet sliding surfaces shall be bonded by the bearing manufacturer under controlled conditions and in accordance with the requirements of the manufacturer of the approved adhesive system. After completion of bonding, the PTFE surface shall be smooth and free from bubbles. Filled PTFE surfaces shall be polished after bonding until smooth.

PTFE fabric sliding surfaces shall be mechanically attached to a rigid substrate. The fabric shall be capable of carrying loads of 10,000 pounds per square inch without cold-flow.

Tolerances of PTFE surfaces shall be:

- (1) Plan dimensions total design area, $+5$ percent -0 percent.
- (2) Substrate flatness, Class A.

Stainless steel sheets shall be seal-welded around the entire perimeter using techniques that ensure it remains in contact with the backing plate. Finish to be at least 20 micro-inches rms. Flatness to Class A tolerance.

Sole plates shall conform to:

- (1) Plan dimensions less than or equal to 30 inches, -0 inch $+3/16$ inch.
- (2) Plan dimensions over 30 inches, -0 inch $+1/4$ inch.
- (3) Centerline thickness, $-1/32$ inch $+1/8$ inch.
- (4) Flatness of surface in contact with steel beams, Class B, in contact with poured in place concrete, none, in contact with stainless steel sliding surface, Class A, in contact with another steel plate, Class B.
- (5) No part shall be thinner than $3/4$ inch.
- (6) Bevels shall be machined to an angular tolerance of ± 0.002 radian.
- (7) Flatness of bevelled surfaces shall be Class A.

Guide bars shall conform to:

- (1) Length, unless integral with plate, $\pm 1/8$ inch.
- (2) Section dimensions, $\pm 1/16$ inch.
- (3) Flatness where it bears on another plate, Class A.
- (4) Bar-to-bar, nominal dimensions, $\pm 1/32$ inch.
- (5) Not more than $1/32$ inch out of parallel.

The overall bearing height shall not be more than $1/8$ inch or less than $1/16$ inch under nominal dimensions. Edges shall be broken and not sharp.

9. Testing:

- a. **General:** Testing shall be performed on test bearings as specified herein to ensure compliance with the specification. As soon as all bearings have been manufactured for the project, the Contractor shall notify the Engineer, who will select test bearing(s) at random from the lot. Manufacturer's certification of conformance with applicable requirements for the steel, elastomeric pads, preformed fabric pads, PTFE and other materials used in the construction of the bearings shall be furnished along with notification of fabrication completion. Testing shall be performed at the manufacturer's plant. Bearing capacities that exceed the manufacturer's testing capacity shall be tested at an approved testing laboratory. If suitable test equipment is not available in the United States, alternative testing/inspection shall be agreed between the Engineer and the manufacturer. The Engineer may witness the testing.

- b. **Sampling:** Tests shall be performed on randomly selected samples from the production bearings. One bearing per lot shall be tested. A lot shall be defined as the smallest number of bearings as determined by the following criteria:

- (1) One lot shall not exceed a single contract or project quantity.
- (2) One lot shall not exceed 25 bearings.

A lot shall consist of those bearings of the same type within a load category. Bearing types shall be fixed type bearings or expansion type bearings. Guided and non-guided expansion bearings will be considered a single type.

One load category shall consist of bearings of differing vertical load capacity within a load range as follows:

- Bearings less than or equal to 1000 kips, the load category shall be based on a range of capacity of 500 kips.
- Bearings greater than 1000 kips capacity but less than or equal to 3000 kips capacity, the load category shall be based on a range of 1000 kips.
- Bearings in excess of 3000 kips capacity, the load category shall be based on a range of 2000 kips.

- c. **Friction test:** A sample from each lot of expansion bearings shall be tested. Specially made bearings shall not be used; only actual bearings to be used in the project shall be tested. The test method and equipment shall be approved by the Engineer and include the following:

- (1) The test shall be arranged so that the coefficient of friction on the first movement of the manufactured bearing can be determined.
- (2) The bearing surface shall be cleaned prior to testing.
- (3) The test shall be conducted at the maximum working stress for the PTFE surface with the test load applied for 12 hours prior to measuring the friction.
- (4) The first movement static and dynamic coefficients of friction shall be determined at a sliding speed of 1 inch per minute or less and shall not exceed the following:

Materials	Bearings Pressure (psi)		
	500	2000	3500
Unfilled PTFE, Fabric containing PTFE Fibers, PTFE-Perforated Metal Composite	0.08	0.06	0.04
Filled PTFE	0.12	0.10	0.08
Interlocked Bronze and Filled PTFE Structures	0.10	0.07	0.05

The bearing specimen shall be subjected to a minimum of 100 movements of at least 1 inch of relative movement and if the facility permits, the full design movement, at a speed of less than 12 inches per minute. After cycling, the static and dynamic coefficients of friction shall be determined again at a speed of less than 1 inch per minute and shall not exceed the specified coefficient of friction. The bearing shall show no appreciable sign of bond failure or other defects.

- d. **Proof load test:** One bearing shall be tested from each production lot of fixed and expansion bearings. Load shall be applied to the test bearings equal to 150 percent of the rated design capacity of the bearing and simultaneously rotated 0.02 radians or the design rotation, whichever is greater, for 1 hour. During test or subsequently upon disassembly, the bearing shall show no sign of deformation or extrusion of elastomer or PTFE.

- e. **PTFE bond test:**

Bearings with sheet PTFE primary surfaces: At the option of the Engineer, one bearing from each production lot shall have a 180-degree peel test performed on the primary PTFE sliding surface in accordance with ASTM D 903. The minimum peel strength shall be 20 pounds per inch.

Bearings with fabric PTFE primary sliding surfaces: One bearing from each production lot shall have the primary PTFE tested in shear as follows: The component carrying the fabric PTFE (or complete bearing at the option of the manufacturer) shall be subjected to the maximum vertical design load of the bearing and simultaneously, but transversely, a load equal to 13 percent of the vertical design load for a period of 1 minute. Slip or creep shall not exceed 1/8 inch during the test.

- f. **Bearings represented by test specimens complying with these requirements:** Such bearings will be approved for use in the structure.

10. **Shipping and packing:** Bearing assemblies including sole and masonry plates shall be securely fixed together as units so that they may be shipped to the jobsite and stored without relative movement of the bearing parts or disassembly at any time. Bearings shall be wrapped in moisture-resistant and dust-resistant material to protect against shipping and jobsite conditions. Care shall be taken to ensure that bearings at the jobsite are stored in a dry sheltered area free from dirt or dust until installation. Each completed bearing shall have its components clearly identified and marked on its top as to location in each structure in the project in conformity with the plans.

When bearings are to be inspected on site, they shall be inspected within 1 week of arrival and may not be disassembled except under the supervision of the manufacturer. Following inspection, the wrapping shall be reapplied and the bearings kept clean until installation.

Removal of sole and top plates of bearings for separate attachment to the structure is not permitted except under the direct supervision of the manufacturer and with the permission of the Engineer.

11. **Installation:** Bearings shall be evenly supported over their upper and lower surfaces under all erection and service conditions. Bearings shall be lifted by their undersides only or specially designed lifting lugs. When installing bearings, care shall be taken to avoid damage to and contamination of bearing surfaces.

The centerlines of the bearing assembly shall be aligned with those of the substructure and superstructure. On guided bearings, special care must be taken to align properly the guiding mechanism with the designated expansion direction of the structure.

Bearing straps or retaining clamps shall be left in place as long as possible to ensure that the parts of bearings are not inadvertently displaced relative to each other. Care shall be taken to remove straps or clamps before normal structural movement takes place, such as post-tensioning.

The upper part of expansion and guided expansion bearings shall be located relative to the base of the bearing to compensate for deviations from normal atmospheric temperature.

When bearings will sit directly on concrete with only an elastomeric, preformed fabric or lead sheet beneath the bearing, concrete bearing seats shall be prepared at the correct elevation and bush-hammered or dressed to the following flatness tolerance:

- a. Bearing seats less than or equal to 30 inches long, 1/16 inch.
- b. Bearing seats over 30 inches but less than or equal to 45 inches, 3/32 inch.
- c. Bearing seats over 45 inches, 1/8 inch.
- d. There shall be no projecting irregularities exceeding 1/32 inch.
- e. Bearing seats shall be level within 1:200 slope.

Where grouted bearing seats are used, the grout shall be the non-shrink type and of the strength specified on the contract drawings but not less than the concrete strength in the main support. Grout shall be placed at even density beneath the entire bearing surface without any voids or hard spots. Grout shall be allowed to reach optimum strength before placing any load on the bearing.

The mating surface of the superstructure shall be level within a slope of 1:200. There shall be no local projecting irregularities exceeding 1/32 inch.

The Contractor shall repair any damage to bearing finishes following installation.

Welding procedures shall be established by the Contractor to restrict the maximum temperature reached by the bonded PTFE surfaces to a maximum of 300 degrees F and to restrict the maximum temperature reached by the elastomer (neoprene or natural rubber) to 250 degrees F. Temperatures shall be determined by temperature-indicating wax pencils or other suitable means. No load shall be transmitted to the bearings until erection of structural steel for spans contiguous to the bearing is substantially complete. Field welding of bearing plates shall be accomplished under the no load condition.

Particular care shall be exercised to mask and protect the PTFE and polished stainless steel surfaces to protect them from blast abrasives and paint application during construction.

12. **Shop drawings:** Shop drawings shall be submitted to the Engineer for review in accordance with the requirements of Section 105.10. These drawings shall include, but not be limited to, the following:
 - a. Plan and elevation view and section elevation of the bearing.
 - b. Complete details of all components and sections showing all materials incorporated into the bearing.
 - c. All ASTM or other material designations.
 - d. Vertical and horizontal load capacity.
 - e. Rotation and movement capacity.
 - f. Compression stress on all sliding surfaces, and elastomeric surfaces, at maximum and minimum design loads.
 - g. Complete design calculations.
 - h. Shop paint or coating requirements.
- (b) **Steel Plates, Shapes, and Bars:** Unless galvanizing is specified, items shall be painted in accordance with the plans.
- (c) **Bronze Plates:** Sliding surfaces of bronze plates shall be polished.
- (d) **Copper-Alloy Plates:** Finishing of rolled copper-alloy plates will not be required provided their surfaces are plane, true, and smooth.
- (e) **Self-Lubricating Plates:** Plates shall be fabricated from cast bronze or rolled copper alloy.

Sliding surfaces of plates shall be provided with annular grooves or cylindrical recesses or a combination thereof, which shall be filled with a lubricating compound. The lubricating compound shall be compressed into recesses under sufficient pressure to form a nonplastic lubricating inset. The inset shall comprise at least 25 percent of the total area of the plate. The frictional coefficient shall be not more than 0.10. The compound shall be free from material that will cause abrasive or corrosive action on metal surfaces and able to withstand extremely high pressures and atmospheric elements over long periods of time.

Items shall be the standard products of the manufacturer of such materials for the application.

Prior to assembly, the steel surface that will bear on the self-lubricating bearing plate shall be thoroughly lubricated with additional antioxidant lubricant furnished by the manufacturer. Coatings shall be removed before application of antioxidant lubricant.

- (f) **Elastomeric Pads:** Care shall be taken in fabricating pads and related metal parts so that effects detrimental to their proper performance, such as uneven bearing and excessive bulging, will not occur.
- (g) **Placement:** Bearing plates or pads shall have a uniform bearing over the entire area. Provision shall be made to keep plates or pads in the correct position during erection of beams or placement of concrete.

Elastomeric pads and other flexible bearing materials shall be placed directly on masonry surfaces that have been finished to a roughness equivalent of a No. 36 to No. 46 grit. Pads, bearing areas, or bridge seats and metal bearing plates shall be thoroughly cleaned and free from oil, grease, and other foreign materials. Metal bearing plates or bottoms of prefabricated beams that are to bear on elastomeric pads shall be coated with epoxy, Type EP-4 or EP-5, conforming to the requirements of Section 243 and then surfaced with a No. 36 to No. 46 silicon carbide or aluminum oxide grit. Bearing areas shall be finished to an equivalent roughness.

Metal bearing plates shall be bedded on bridge seats as follows: The bridge seat bearing area shall be thoroughly swabbed with No. 1 paint, and three layers of duck, 12 to 15 ounces per square yard, shall be placed on it, each layer being thoroughly swabbed with paint on its top surface.

Superstructure shoes or pedestals shall be placed in position while paint is plastic. As an alternate to duck and paint, sheet lead of at least 0.1 inch in thickness or preformed fabric bedding material at least 1/8 inch in thickness may be used when called for on the plans or approved in writing by the Engineer.

Rockers or other expansion devices shall be centered and aligned so that the vertical axis will be vertical at 60 degrees F.

- (h) **Anchors:** Anchor bolts, nuts, and washers shall be painted or galvanized on superstructures having steel beams or girders. When superstructure units are concrete, anchor bolts, nuts, and washers, including bearing assemblies and insert plates, shall be galvanized. Shop paint shall cover the threaded end to 1 inch below the surface of masonry. Anchors shall be positioned to provide the required fit with bearing plates. Anchors shall be cast into the masonry and positioned by means of templates or other methods that will hold them securely in the correct position until concrete has set. The method of setting shall allow for proper finishing of concrete bearing areas.

Anchors that are not designed to project through bearing plates shall be checked for proper projection above the masonry bearing area immediately prior to placement of bearing plates and beams. Nuts on anchor bolts at expansion ends shall be adjusted to permit free movement of the span.

Angles for anchor assemblies to be attached to sides of concrete beams shall not be installed until beams have received their full dead load and supporting falsework has been removed.

408.04—Measurement and Payment

Metal bearing and expansion plates and anchors will be measured by shop scales in pounds of actual material placed in accordance with the plans. When not a separate pay item, the Department will include the weights of plates and anchors in the weight of structural steel or reinforcing steel for payment. When a pay item, bearing plates will be paid for at the contract unit price per pound and shall include elastomeric and other flexible bearing pads. Bearings and anchors for prestressed concrete deck units will be paid for in accordance with Section 405. The cost of bedding and preparation for metal bearing plates shall be included in the prices for superstructure items. This price shall include furnishing material, galvanizing, painting, and lubricating.

Payment will be made under:

Pay Item	Pay Unit
Bearing plates	Pound

SECTION 409—STEEL GRID FLOORS**409.01—Description**

This work shall consist of constructing a steel grid floor.

409.02—Materials

Materials shall conform to the requirements of Section 227.

409.03—Procedures

The floor shall conform to the requirements for the design of steel grid floors in AASHTO's *Standard Specifications for Highway Bridges*.

- (a) **Arrangement of Sections:** Where main elements are normal to the centerline of the roadway, units shall generally be of such length as to extend over the full width of any roadway up to 40 feet. In every case, units shall extend over at least three panels. Where joints are required, ends of main floor units shall be welded at joints over their full cross-sectional area or otherwise connected to provide full continuity in conformance with the manufacturer's recommendations.

Where main elements are parallel with the centerline of the roadway, sections shall extend over at least three panels and ends of abutting units shall be welded over their full cross-sectional area or otherwise connected to provide full continuity in accordance with the approved design.

- (b) **Provision for Camber:** Steel units so rigid that they will not readily follow the camber required shall be cambered in the shop. To provide a bearing surface normal to the crown of

the roadway, the stringers shall be canted or provided with shop-welded beveled bearing bars. If beveled bars are used, they shall be placed along the centerline of the stringer flange, in which case the design span length shall be governed by the width of the bearing bar instead of the width of the stringer flange.

Longitudinal stringers shall be cambered at the mill or provided with bearing strips so that the completed floor after dead-load deflection shall conform to the longitudinal camber shown on the plans.

- (c) **Field Assembly:** Areas of considerable size shall be assembled before the floor is welded to its supports. Main elements shall be made continuous, and sections shall be connected together along their edges by welding of bars. Connections shall be approved by the Engineer.
- (d) **Connection to Supports:** The floor shall be connected to its steel supports by welding. Before any welding is done, the floor shall be loaded to make a tight joint with full bearing or clamped down. The location, length, and size of the welds shall be as approved but in no case less than the manufacturer's standards.

Ends of main steel units of the slab shall be securely fastened together at sides of the roadway for the full length of the span by means of steel plates or angles welded to ends of main units or by encasing ends with concrete.

- (e) **Welding:** Welding shall conform to the requirements of Section 407.
- (f) **Damaged Galvanized Coatings:** Damaged coatings shall be repaired in accordance with the requirements of Section 233.
- (g) **Concrete Filler:** Floors with open bottom flanges shall be provided with bottom forms of metal or wood to retain the concrete filler.

If metal form strips are used, they shall fit tightly to bottom flanges of floor units and be placed in short lengths extending approximately 1 inch beyond the edge of each support. The form shall be such as will result in the adequate bearing of the slab on the support.

Concrete shall be placed and cured in accordance with the requirements of Section 404 and thoroughly consolidated by vibrating the steel grid floor. The vibrating device and manner in which it is operated shall be subject to the approval of the Engineer.

- (h) **Painting:** Steel grid flooring furnished without galvanizing but with a shop coat of paint shall be painted in accordance with the requirements of Section 411.

If a structural steel plate is used on the bottom of a filled floor, the bottom surface of the plate shall be painted in accordance with the requirements of Section 411.

409.04—Measurement and Payment

Steel grid floors will be measured in square feet of surface area, complete-in-place, and will be paid for at the contract unit price per square foot.

Payment will be made under:

Pay Item	Pay Unit
Steel grid floor	Square foot

SECTION 410—RAILINGS AND PARAPETS

410.01—Description

This work shall consist of furnishing and installing railings, bridge median barriers, and concrete parapets true to the line, grade, and dimensions shown on the plans or as established by the Engineer.

410.02—Materials

- (a) **Concrete** shall conform to the requirements of Section 217. In the event the Contractor places concrete by the extrusion method, the slump may be less than 2 inches, the air content shall be no less than 4 percent, and the size of the coarse aggregate shall be no less than No. 7.
- (b) **Steel reinforcement** shall conform to the requirements of Section 223.
- (c) **Steel for metal parapets** shall conform to the requirements of Section 226.
- (d) **Hydraulic cement mortar and grout** shall be nonshrinking and shall conform to the requirements of Section 218.
- (e) **Aluminum railings and materials** shall conform to the requirements of Section 229.
- (f) **Anchor bolts** shall conform to the requirements of Section 226.02(c).
- (g) **Grounding materials** shall conform to the requirements of Section 238.

410.03—Procedures

- (a) **Post Alignment:** Posts shall be normal with respect to the profile grade and plumb in the transverse direction regardless of the cross slope.
- (b) **Metal Railings:** Fabrication and erection shall be performed in accordance with the requirements of Section 407. Working drawings shall be furnished in accordance with the requirements of Section 407. In welded railing, exposed joints shall be finished by grinding or filing to give a neat appearance.

When alternate metal railings are permitted, bridges under any one contract shall have the same type of railing.

Metal railings shall be carefully adjusted prior to being fixed in place to ensure proper matching at abutting joints and correct alignment and camber throughout their length. Holes

for field connections shall be drilled wherever possible with railing in place at the proper grade and alignment.

Abutment ends of metal railings and metal parapets shall be grounded. Grounding conductor shall be bare or insulated (green) copper. Grounding electrode(s) shall be installed in accordance with the requirements of Section 700 and shall conform to the requirements of the NEC. All sections of metal railings, movable joints of metal railings, metal parapets, and the gaps in the metal railings created by the concrete pole supports or other design modifications shall be bonded internally to maintain continuity. Grounding conductors shall pass through bridge parapets and backwalls in 1 inch conduit or raceway to a point 4 to 8 inches below the finished grade and attached to a grounding electrode(s) with a minimum of 8 feet contact with soil. Each run of grounding conductor shall be provided with a 4-inch exposed loop at expansion joints and at termination points. Each metal rail section adjacent to the next metal railing shall be tested for continuity to ensure system grounding. The Contractor shall test the grounding electrode(s) after installation using the fall of potential (three-point measurement) method. Testing shall be documented and the documentation submitted to the Engineer.

1. **Painting:** Steel or iron railing that is not galvanized shall be given one shop coat and three field coats of paint after erection. Painting shall be performed in accordance with the requirements of Section 411.
2. **Anchorage:** Metal-railing anchorages in concrete shall be placed in accordance with the requirements of Section 404 and Section 408.
3. **Aluminum railings:** Components of railing shall be designed for adequate structural strength. Castings shall have a thickness of at least 1/4 inch, and other units shall have a thickness of at least 3/16 inch.

Aluminum in contact with concrete shall be coated with an approved aluminum-impregnated caulking compound. Aluminum surfaces in contact with metals other than stainless or galvanized steel shall be insulated with approved materials.

- (c) **Concrete Railings, Bridge Median Barriers, and Parapets:** Concrete railings or parapets shall not be placed until centering or falsework for the span has been released, rendering the span self-supporting.

Railings, bridge median barriers, and parapets shall be constructed in accordance with the requirements of Section 404 for the class of concrete specified on the plans and shall be given a Class I finish. Care shall be taken to secure smooth and tight-fitting forms that can be rigidly held to line and grade and removed without damage to concrete. Concrete parapets and median barriers shall be constructed within an allowable tolerance of $\pm 1/2$ inch for overall depth and overall width, $\pm 1/4$ inch for the width of the upper portion of the barrier, and $\pm 1/4$ inch per 10 feet for horizontal alignment.

Forms for concrete railing shall be fabricated of single-width boards lined with approved material. Form joints in plane surfaces will not be permitted.

Moldings, panel work, and bevel strips shall be constructed with neatly mitered joints. Corners in finished work shall be true; sharp; clean cut; and free from cracks, spalls, or other defects.

Reinforcing steel shall be placed in accordance with the requirements of Section 406.

Expansion joints shall be constructed so as to permit freedom of movement. After all other work is completed, loose or thin shells of mortar likely to spall under movement shall be removed from expansion joints by means of a sharp chisel.

In the event the Contractor elects to construct railing, parapet, or median barrier by the extrusion method, construction shall conform to the following:

1. In the event the bridge deck needs to be widened or additional reinforcing steel placed in the railing, parapet, or median barrier to accommodate the extrusion machine, the Contractor shall submit all necessary details for approval. Widening the bridge deck or placing additional reinforcing steel shall be at the Contractor's expense.
2. The extrusion machine shall be equipped with internal vibrators to consolidate concrete along the face and adjacent joints in one complete pass of the machine. This shall be accomplished in such a manner that a minimum of hand finishing will be required to produce a dense homogenous finish, free from voids and honeycomb.
3. When the plans require horizontal drains in the railing, parapet, or median barrier, the Contractor shall submit his proposed method of forming drains to the Engineer for approval.
4. Deflection and expansion joints shall be grooved in accordance with the plans immediately after the extrusion process, and required saw cutting shall be completed the same day the concrete is placed.

410.04—Measurement and Payment

Railing will be measured in linear feet along the centerline of the top rail between the extremities of each railing without deductions for breaks or interruptions. When railing is not a pay item, the cost thereof shall be included in the price for other appropriate items. When a pay item, railing will be paid for at the contract unit price per linear foot. This price shall include furnishing rails, rail posts, post bearing pads, anchor assemblies, and sleeves; furnishing and installing grounding materials; painting; galvanizing; reinforcing steel necessary; and concrete where applicable.

Parapets will be measured in linear feet along the face of the parapet, and **bridge median barrier** will be measured in linear feet along the barrier centerline. Parapets and bridge median barriers will be paid for at the contract unit price per linear foot. This price shall include furnishing and installing materials designated above the bridge deck surface, including anchorage material, reinforcing steel, junction boxes, conduits, and/or raceways used for rail grounding.

Payment will be made under:

Pay Item	Pay Unit
Railing (Type)	Linear foot
Parapet (Type)	Linear foot
Bridge median barrier (Type)	Linear foot

SECTION 411—PROTECTIVE COATING OF METAL IN STRUCTURES

411.01—Description

This work shall consist of preparing and coating ferrous metal surfaces on new and existing structures, including, but not limited to, main units, diaphragms, bearing assemblies, shop and field contact surfaces, surfaces in contact with concrete, parts designed to be embedded in concrete, rails, expansion joints, drainage systems, utility lines, and attachments in accordance with these specifications.

Classification of Structures: Existing structures will be classified on the plans by the Department as follows:

Type A: Structures that have no coatings or that have coatings that do not contain hazardous materials.

Type B: Structures that have coatings that may generate hazardous wastes.

Should the structure require application of a coating and no classification is specified in the contract documents, the Contractor shall bid Type B.

Galvanized surfaces and surfaces protected with other coatings shall not be coated unless otherwise specified. Cast, ductile, and nodular iron castings need not be coated. Application procedures not specified herein shall be as specified by the manufacturer and approved by the Engineer.

411.02—Materials

- (a) **Coating** shall conform to the requirements of Section 231.
- (b) **Water used in cleaning operations** shall be potable. Recycled water shall be filtered prior to reuse. Recycled water shall be used only on the bridge from which it was generated and shall be subsequently tested in accordance with the requirements of Section 411.04(a) and disposed of.
- (c) **Abrasives used in cleaning operations** shall be one of the following categories:
 1. **Expendable** abrasives shall conform to the requirements of SSPC-AB 1, Type I or Type II, Class A, except that silica and quartz sands will not be allowed. The abrasive shall not contain total levels of any of the heavy metals listed in 40 CFR 261.24, Table 1, in excess of 20 times the specified regulatory leachable limits. The abrasive shall be selected from the Department's approved products list.
 2. **Recyclable** abrasives, newly manufactured or re-manufactured steel, shall conform to the requirements of SSPC-AB 3. Recycled abrasive shall be examined by the Contractor for oil contamination prior to start up and at least once per 8-hour shift in accordance with the requirements of VTM-82. Recycled abrasive shall not contain non-abrasive residue in excess of the requirements of SSPC-AB 2.

411.03—Certifications

- (a) **SSPC QP-1 Certification:** the Contractor shall be certified to perform coating operations on all new and existing steel structures, Types A and B. Prior to performing coating applications, the Contractor shall submit proof of certification complying with the criteria of SSPC QP-1, Standard Procedure for Evaluating Qualifications of Painting Contractors, Field Applications in Complex Structures. This certification requirement will be waived for structural steel repairs and the replacement of structural components including, but not limited to, diaphragms, bearing assemblies, cross frames, stiffeners, connector plates, and beam repairs provided such work is performed in accordance with all applicable OSHA and environmental requirements for the type and scope of work specified.
- (b) **Certified Industrial Hygienist (CIH) or SSPC QP-** If the project work involves the removal of greater than 100 square feet of coating from a Type B structure, the Contractor shall maintain an SSPC QP-2 certification and assign an SSPC QP-2 Supervisor/Competent Person to oversee activities to protect the environment throughout the project. Alternatively, the Contractor may employ a Certified Industrial Hygienist currently certified by the American Board of Industrial Hygiene to perform the aforementioned oversight activities. The environmental plan described in Section 411.08 shall be prepared by the SSPC QP-2–certified organization or approved by a CIH. The SSPC QP-2 Supervisor/Competent Person or CIH shall be present during startup, surface preparations, removal operations, and waste removal/disposal activities to ensure environmental protection. The SSPC QP-2 Supervisor/Competent Person or CIH shall submit written certification at the completion of the project that the plan fully complied with all applicable regulations and was fully implemented.
- (c) **Professional Engineer:** If the project involves the erection of any containment structure with the bridge serving as the primary means of support, the Contractor shall describe such system as specified in Section 411.08(a) and provide certification by a Professional Engineer, licensed in the Commonwealth of Virginia. This requirement will be waived for any containment structure with a total weight-bearing capacity of less than 1,000 pounds.

411.04—General Surface Preparation and Application Standards

Prior to being coated, surfaces shall be free from rust, loose or brittle paint, chalking, oil, grease, salt contaminants, dirt, and other substances that would prevent coating from adhering tightly. Surfaces shall be prepared in accordance with SSPC specifications. Surface conditions and finished surface profiles shall conform to SSPC-Vis Standards or National Association of Corrosion Engineers (NACE) Comparators.

Should an area of steel that has previously been cleaned become soiled, contaminated, or rusted, the Contractor shall reclean the area to the satisfaction of the Engineer prior to application of coating at no additional cost to the Department.

Regardless of the method of cleaning, surface imperfections described in the “*Procedures Following Blast Cleaning and Immediately Prior to Painting Section*” of SSPC-SP 10 and any other matter that will prohibit a smooth unobstructed surface for the application of the specified coating, shall be removed.

- (a) **Application Conditions:**

Preparing Surfaces To Be Coated: The Contractor shall keep contaminants from coming in contact with surfaces during surface preparation and coating operations. Unsealed connections, small cracks, cavities, and depressed areas on flanges shall be filled in accordance with the requirements of Section 407.

Prior to application of coating, the surface shall be prepared in accordance with one or more of the following methods. Except as provided herein, surfaces to be coated shall be cleaned in accordance with the requirements of Method 1 prior to the use of other surface preparation methods.

1. **Method 1:** Solvent, emulsion, or steam shall remove oil, dust, dirt, grease, concrete, chalking, and salt in accordance with the requirements of SSPC-SP-1. Contaminated solvent shall be removed before it evaporates by wiping or rinsing with clean solvents to prevent a film of contaminants from remaining on the surface. Solvent wiping may be required between coats. Solvents used in the work shall be those recommended by the paint manufacturer.
2. **Method 2:** Hand-tool cleaning shall remove loose coating, loose rust, and loose mill scale in accordance with the requirements of SSPC-SP-2.
3. **Method 3:** Power-tool cleaning shall remove loose coating, loose rust, and loose mill scale in accordance with the requirements of SSPC-SP-3.
4. **Method 4:** Power-tool cleaning shall remove coating, rust, and mill scale to bare metal in accordance with the requirements of SSPC-SP-11.
5. **Method 5:** Abrasive blast cleaning shall remove visible coating, rust, and mill scale in accordance with the requirements of SSPC-SP-10/NACE No. 2. Abrasives shall be recycled unless otherwise specified or approved by the Engineer. If an expendable abrasive is used on a Type B structure, it shall be used in conjunction with a process that will allow beneficial reuse of the expended product. Recyclable abrasive containing rust that adversely affects the cleanliness of the blasted surface will not be permitted.

After blast cleaning, the surface profile shall be from 1 to 3 mils in a dense uniform pattern of depressions and ridges as determined by a spring micrometer with surface profile replica tape in accordance with ASTM D4417, Method C. Both shop-blasted and field-blasted surfaces shall be coated within 24 hours. If rust bloom develops, blast cleaning shall be repeated at no additional cost to the Department.

6. **Method 6:** Brush-off blasting shall remove loose or brittle coating, loose rust, and loose mill scale in accordance with the requirements of SSPC-SP-7/NACE No. 4.
7. **Method 7:** Low-pressure water cleaning shall remove dust, debris, and salt contaminants. The pressure washer shall be capable of achieving 2,000 pounds per square inch at the nozzle when used prior to blast cleaning and 5,000 pounds per square inch at the nozzle when used to remove loose or brittle coatings. When the power washing equipment is used, the nozzle shall be maintained no more than 10 inches from the surface. Any detergents or cleaners used in conjunction with this method shall be those recommended by the coating manufacturer and as approved by the Engineer. Method 7 can be used exclusively (i.e., in lieu of Method 1) for the cleaning of new shop-primed or

new field-primed steel provided that no oil or grease is present or that oil and grease are removed separately by Method 1.

Regardless of which method of surface preparation is used, the Contractor shall collect and contain solid and liquid waste, except for new steel cleaned by Method 7. Any water generated from cleaning new shop-primed or new field-primed steel by Method 7, provided that no detergents or cleaners were used, shall be directed to the bridge approaches or stream bank but shall not be directly discharged into any waterway. This exception does not apply to waste generated from surface preparation of galvanized steel, which shall be captured and disposed in accordance with the requirements of Section 411.07(b). The waste material(s) generated from work performed on Type B structures shall be tested in accordance with EPA Method 1311, Toxicity Characteristic Leaching Procedure (TCLP), and corresponding EPA 6000 or 7000 series metals analytical method for, but not limited to, the following metals to determine if the waste material(s) requires management as hazardous waste: arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver; the exception to this testing protocol is that waste generated from abrasive blasting with recycled steel abrasives for Method 5 shall be tested for total concentrations of the aforementioned heavy metals in lieu of the TCLP analysis. Waste material(s) shall be disposed of in accordance with all federal, state, and local regulations.

(b) **Physical Application:** Coatings shall be applied in accordance with SSPC-PA 1. Coatings shall not be applied under any of the following conditions unless recommended by the manufacturer and approved by the Engineer:

1. Air, coating, or metal temperature is below 40 degrees F.
2. Air, coating, or metal temperature is expected to fall below 40 degrees F before the coating has cured.
3. Snow, sleet, or rain is falling.
4. Moisture is visible on metal.
5. Humidity is above 85 percent.
6. The temperature of the steel or metal surface to be coated may cause blistering as indicated in the manufacturer's product data sheet.
7. The steel surface temperature is less than 5 degrees F above the dew point or is expected to fall to that point before the coating has dried or cured.

In no case shall System W as shown in Table IV-6 be applied unless the air, steel surface, and material temperature is above and maintained above 50 degrees F and rising.

Prior to application of coatings, the surface shall be dry. Coatings shall be applied in a neat and orderly manner by brushing, rolling, or spraying as recommended by the manufacturer. However, rollers, daubers, or sheepskins shall not be used to apply zinc-rich coatings.

Zinc-rich coatings may be applied by brush, limited to isolated areas of 1 square foot or less.

TABLE IV-6
Coating Systems

System	Coat	Coating	Min. Dry-Film Thickness (DFT) (mil)
B	Primer Intermediate Finish	Zinc-rich (from Department's approved products list)	
F	Primer	No. 14	5.0
	Finish	No. 14 or as specified in Section 231.03(c) or 231.03(d)	5.0
W	Primer	No. 101 Federal No. 595-30045	2.0-4.0
	Intermediate	No. 102, White	2.0-4.0
	Finish	No. 103*	2.0-4.0**

* Color as specified. If not specified, color shall be Federal No. 595-26307.

** DFT shall be no less than the specified thickness; however, it shall completely cover the intermediate coat.

Coatings shall be applied in a manner to provide a tight film of specified uniform thickness well bonded to metal or underlying coating, including crevices and corners, and shall be free from laps, streaks, sags, runs, overspray, dryspray, shadow-through, skips, excessive film build-up, mud cracking, misses, and other defects.

Beam edges, bolts, washers, and nuts shall receive a stripe coat prior to the full coat application. If a multicoat system is being applied, beam edges, bolts, and nuts shall be striped prior to each coat except that a stripe coat will not be required for a zinc-rich primer. Stripe coatings shall dry or cure to touch before overcoating.

Deficient, impaired, or damaged areas of each coat shall be repaired using material from the Department's approved products list. Two-component, solvent-based, inorganic zinc shall be considered cured when only trace amounts are removed in accordance with the requirements of ASTM D4752.

Successive coatings shall not be applied until each preceding coat has dried and cured in accordance with the manufacturer's recommendations and has been approved by the Engineer. Coatings shall be applied in accordance with the requirements of Table IV-6.

Mixing: Coatings shall be mixed in accordance with the manufacturer's instructions. Zinc-rich coatings shall be applied from containers equipped with a mechanical agitator, which shall be in motion throughout the application period unless otherwise specified by the manufacturer. Coatings shall not be thinned beyond the volatile organic compound (VOC) limit or the manufacturer's recommendation, whichever is the most restrictive. Individual components of multicomponent coatings shall be mixed separately prior to mixing with other components of the kit. Mixing shall be by use of a power mixer. Multicomponent material shall not be mixed in proportions less than the packaged quantities.

- (c) **Quality Control: Measuring Film Thickness:** The dry-film thickness of coating will be determined by the Engineer with a Tooke gage when the thicknesses of previous coatings are not known and with a magnetic dry-film thickness gage when the previous thickness is

known. The magnetic gage will be used and calibrated in accordance with the requirements of SSPC-PA-2. The Contractor shall repair test areas at no additional cost to the Department. The method of repair shall conform to methods as outlined in this section or as approved by the Engineer.

- (d) **Record Keeping and Protective Coating Identification:** The Contractor shall maintain a record that establishes and describes the location and limits of the work area where protective coating removal or application has been accomplished. Such records shall be maintained and completed on a daily basis and shall provide at a minimum the following information: Contractor's name, date, time work began, time work completed, ambient air and structure temperature and relative humidity ranges during coating operation, surface cleanliness and profile measurements, and dry-film thickness and name of coating system applied. The record shall include a map indicating areas where the protective coating has been applied as accurately located on the actual bridge structure except for structures as described in Section 411.05(b)3. The daily record and map format shall meet the approval of the Engineer and shall be established prior to commencement of work. The daily records and maps shall be maintained in a three-ring binder throughout the duration of the project. Prior to final acceptance, the Contractor shall submit to the Engineer the three-ring binder complete and shall certify that all information contained therein is factual and correct.

For new steel and after recoating an existing structure, after the final coat has cured, the Contractor shall stencil on the structure a legend indicating the type of coating system(s) and the month and year in which it was applied. The legend shall be placed inside a fascia stringer near an abutment at a location approved by the Engineer and shall be black in color.

411.05—Existing Structures

Coated steel structures built before 1978 and weathering steel structures may contain mill scale.

- (a) **Bare Steel:** Uncoated weathering steel shall be cleaned in accordance with the requirements of Method 5 and shall be coated with System B. The following areas of weathering steel shall be coated as indicated:
1. Areas within 5 feet of a deck joint, including, but not limited to, cross frames, diaphragms, stiffeners, connector plates, girders, and beams.
 2. The entire outside surface of fascia girders and beams, including the underside of the bottom flange.

These areas shall be thoroughly cleaned to no less than 6 inches outside the area to be coated and shall be coated with System B.

- (b) **Coating Remaining:** Coating application will be performed as follows:
1. **Prepare and spot coat existing structure:** Surfaces being coated shall be prepared in accordance with Method 1 followed by Method 7 using a pressure of 5,000 pounds per square inch at the nozzle. Rust shall be removed in accordance with Method 4 or Method 5. Prepared areas shall be spot-primed with primer from the system specified. Intermediate and finish coat shall be applied to spot-primed areas only and shall be feathered into the existing finish coat to produce a uniform homogeneous appearance with

the existing structure. The coating system shall be as specified on the plans. If no system is specified, System W shall be used.

2. **Prepare and overcoat existing structure:** Prepared areas shall be spot-primed with primer from the system specified. Intermediate and finish coat shall be applied to the entire structure. The coating system shall be as specified on the plans. If no system is specified, System W shall be used.

The entire structure shall be cleaned in accordance with the requirements of Method 1 followed by Method 7 using a pressure of 5,000 pounds per square inch at the nozzle. Areas to be primed and coated shall be prepared in accordance with Method 5 or Method 4.

3. **Recoat existing structure:** The entire structure shall be cleaned in accordance with the requirements of Method 1 followed by Method 7 using a pressure of 2,000 pounds per square inch at the nozzle. The entire structure shall be cleaned to bare metal in accordance with Method 5. The structure shall be recoated using System B.
4. **Coating new steel members used to repair existing structure:** Unless otherwise directed or approved by the Engineer, the newly installed steel members shall be cleaned to bare metal in accordance with Method 5. Prepared areas shall extend 6 inches beyond new steel member into the existing structure at the point of repair and shall be spot-primed with primer from the system specified. Intermediate and finish coat shall be applied to spot-primed areas only and shall be feathered into the existing finish coat to produce a uniform homogeneous appearance with the existing structure. The coating system shall be as specified on the plans. If no system is specified, System W shall be used.
5. **Zone coating:** Surfaces shown on the plans or in the Contract as being zone coated shall be cleaned in accordance with the requirements of Method 1 followed by Method 7 using a pressure of 2,000 pounds per square inch at the nozzle. The entire area designated for zone coating shall be prepared in accordance with Method 5.

Areas designated for zone coating shall be primed and coated using a coating system selected from the Department's approved zinc rich paint systems list.

If a winter season elapses between applications of coats, the structure shall be prepared again in accordance with the requirements of Method 1 prior to resuming application of additional coatings and at no additional cost to the Department.

Existing steel on structures to be widened shall not be prepared and coated unless otherwise specified. When specified on the plans for coating, the entire coating on the existing structure shall be removed in accordance with the requirements of Method 5 and the existing structure shall be coated with the same system as required on the new steel.

411.06—New Structures

Non-stainless ferrous metal shall be coated using System B as specified in Table IV-6.

- (a) **Shop Coating:** Metal surfaces to be coated shall be abrasive blast cleaned in accordance with the requirements of Method 5 prior to application of primer. Material shall not be shipped until the primer has cured.

Machine-finished surfaces and/or areas that are to bear on other surfaces in a sliding movement shall not receive an applied protective coating as specified in Table IV-6 but shall be coated with a multipurpose grease or other specified coating prior to shipment.

Erection and weight marks shall be stenciled or painted on structural steel subsequent to application of shop primer. No other lettering shall be allowed.

The following areas of weathering steel shall be coated:

1. Areas within 5 feet of a deck joint, including, but not limited to, cross frames, diaphragms, stiffeners, connector plates, girders, and beams.
2. The entire outside surface of fascia girders and beams, including the underside of the bottom flange.

These areas shall be thoroughly cleaned to no less than 6 inches outside the area to be coated and shall be coated with System B.

Deficiencies and nonconformities shall be satisfactorily corrected prior to shipment.

- (b) **Field Coating:** Field application of coatings shall not be performed until concrete work is completed and forms are removed. Concrete deposited on coated steel surfaces shall be removed. Prior to coating, surfaces shall be cleaned in accordance with the requirements of Method 7 as described in Section 411.04(a) using a pressure of 2,000 pounds per square inch at the nozzle. Uncoated surfaces and deficient or damaged areas shall be cleaned in accordance with the requirements of the coating manufacturer and touch-up primed with a primer from System B.

If a winter season elapses between applications of coats, the structure shall be prepared again in accordance with the requirements of Method 7 at no additional cost to the Department.

After installation and approval by the Engineer, galvanized bolts or bolts protected with approved coatings shall be cleaned with water-based biodegradable cleaner followed by a potable water rinse. Other erection bolts that will be coated shall be degreased and abrasive blasted in accordance with the requirements of Section 411.04. Suitable precautions shall be taken to mask off the surrounding primed area to prevent overblasting. Cleaning agents and rinse water shall be collected and disposed of in accordance with applicable state and federal regulations. After cleaning, bolts shall be coated with the identical intermediate and top-coats being applied to the rest of the structure. If additional surface preparation of galvanized bolts is required, preparation shall be as recommended by the coating manufacturer.

Surfaces that will be inaccessible after assembly and erection shall be coated prior to assembly.

When the superstructure is concrete, the color of bearing assemblies shall be Gray, Federal No. 595-26307.

When the superstructure is weathering steel the topcoat shall be Brown, Federal No. 595–20059. The topcoat color for other structures shall be Gray, Federal No. 595–26307 unless otherwise specified on the plans. When only portions of a structure are designated for coating, the edges of coated areas shall be masked to a straight line.

411.07—Galvanized Surfaces

- (a) **Existing Uncoated:** The surface shall be prepared in accordance with Method 1 or Method 7. Rust shall be removed using Method 2 or Method 3. The surface shall be coated with a coating system from the Department’s approved products list.
- (b) **New Surface:** New galvanized surfaces that are to be coated shall not be quenched or chromate treated by the galvanizer. Prior to coating, galvanized surfaces shall be prepared in accordance with Method 1.

In the event new galvanized material is supplied to the project that has been quenched or chromate treated and the Engineer directs that such material is to be coated, the Contractor shall prepare the surface in accordance with ASTM D 2092, Method A or Method G. If surface preparation is performed in the field, the Contractor shall collect and contain solid and liquid waste. Waste shall be characterized and disposed of in accordance with the requirements of Section 411.08(c) for a Type B structure. Any additional cost for surface preparation, waste collection, waste characterization, and disposal associated with the coating of quenched or chromate-treated galvanized material as directed by the Engineer will be in accordance with the provisions of Section 109.05. The surface shall be coated with a coating system from the Department’s approved products list.

411.08—Environmental Protection

In accordance with the requirements of Section 107, the Contractor shall protect the public and the environment from leaded paint or hazardous material resulting from coating preparation, cleaning, removal operations, blast abrasives, rust, and overspray.

Depositing or dropping waste materials into water, onto the ground, onto roadways, or outside the containment system will not be permitted. Waterways and travel-ways shall be protected against coating drift and overspray. Equipment and containment devices shall arrive at the site in a decontaminated condition and shall be decontaminated prior to relocating or moving unless otherwise properly disposed. Residues from decontamination and any disposable items shall be properly disposed of in accordance with all applicable federal, state, and local regulations.

The Contractor shall at all times be in compliance with these specifications and the regulations of, but not exclusive to, the following agencies: U.S. Environmental Protection Agency, U.S. Department of Transportation, Virginia Department of Environmental Quality, Virginia Department of Labor and Industry, and the U.S. Coast Guard.

- (a) **Environmental Plan:** Where surface preparation operations are required, the Contractor shall submit a detailed site-specific Environmental Plan to the Engineer for Department records and review for completeness only, not approval. The Contractor shall provide one comprehensive plan that covers all facets of operation. No work shall proceed until the Engineer has notified the Contractor that the plan contains all the necessary elements. The Environmental Plan shall include controls for capture, containment, collection, storage, and

transportation of waste material generated by the work. The Contractor shall use the most effective method possible for capture, collection, containment, and transportation operations. Plans shall include measures for accidental spill cleanup.

The Environmental Plan shall be certified by an SSPC QP-2 Supervisor/Competent Person or a CIH currently certified by the American Board of Industrial Hygiene. If the project design involves the erection of a supported containment system with a total weight-bearing capacity of greater than 1,000 pounds, the plan shall also be reviewed and certified by a Professional Engineer registered in the Commonwealth of Virginia as to the design acceptability for the structural load of the containment system on the bridge.

After project award but not less than 3 weeks prior to commencing operations covered by this plan, the environmental plan shall be submitted to the Engineer. Within 2 weeks of receipt, the Engineer will review the submitted plan for completeness. Should deficiencies in the plan exist, the plan will be returned to the Contractor for incorporation of revisions as noted by the Engineer. The Contractor shall make such revisions and submit completed plans for the Engineer's record prior to commencing operations. In no case shall the Contractor begin work prior to the Engineer's receipt and review of a satisfactorily complete plan.

- (b) **Monitoring:** Visual inspections of the containment structures and the dust collector and abrasive recycling equipment shall be continuously performed to detect and control any emissions into the unconfined air space. Emissions will not be permitted outside the containment system. Visual emissions outside the containment system shall immediately be corrected to comply with emission standards. Minimal visible air emissions will be allowed for properly operating vacuum-assisted power tools provided that a secondary means for collecting large particles is employed and the technology is applied using usual and customary industry practices. Excessive emissions caused by improperly operated or functioning equipment shall be immediately corrected. Adequate lighting shall be provided as necessary to aid visual inspections.

Perimeter air monitoring shall be performed, as directed by the Engineer through review comments on the environmental plan submission, using high-volume air samplers equipped for the collection of total suspended particulate (TSP) samples. The filters shall be analyzed for lead in accordance with EPA 40 CFR Part 50, Appendix G, for a minimum of 8 hours per day of operation. Samples shall be collected within 500 feet downwind of paint abatement, dust collection, and abrasive recycling equipment. Perimeter monitoring results shall be maintained below the National Ambient Air Quality Standard for lead (40 CFR Part 50) using the Adjusted Daily Allowance (ADA) procedure outlined in SSPC-Guide 6, Method D. The results of all sample analyses shall be submitted to the Engineer as soon as they are available. Should emissions exceed the limits set herein or material begins to reach the ground or enter State waters, the Contractor shall notify the Engineer and operations shall be halted until such time that corrective actions are implemented.

- (c) **Waste Characterization and Disposal:** Material removed from a Type A structure shall be disposed of as a non-hazardous waste in accordance with the requirements of (d)1 herein.

Material removed from a Type B structure shall be contained, collected, and stored in closed 55-gallon USDOT approved steel drums or portable metal roll-off containment refuse disposal bins. For small quantities of waste, approved 5-gallon containers may be used.

The Contractor shall, with the oversight of the Engineer; collect and provide to the Department samples for analysis at the following frequency:

Containers	Samples
1	1
2-6	2
Over 6	1 for every 3 containers

Samples shall be randomly collected and shall be representative of the contained waste. Waste shall not accumulate for more than 30 days before samples are collected. A laboratory certified by the American Industrial Hygiene Association to perform lead analysis and approved by the Department shall perform the testing. Testing will be performed in accordance with the requirements of Section 411.04(a). The Department shall pay the cost of all tests performed by the laboratory. Waste generated from abrasive blasting with recycled steel abrasive shall be classified as hazardous if the total lead level exceeds 0.01 percent. If the material is declared to be a hazardous waste by the Department, the Contractor shall dispose of the material in accordance with the requirements of Section 411.08(d)3. The Contractor is not relieved from performing waste testing in accordance with the aforementioned procedures by using test results from samples of coatings collected while adhered to the structural steel.

Each structure shall have a separate lockable storage area for waste material located immediately adjacent to the structure. The Contractor shall collect the material at the end of each workday and shall transport the waste material to the storage area in a closed container that will not permit leakage. Each container shall be marked indicating the origin of the material; the date the material was placed in the storage area; and a 24-hour telephone number of the Contractor and Department representative. Prominent warning signs shall be displayed around the perimeter of the storage. The signs shall be located at a distance from the storage area that will allow personnel to read the sign and take the necessary protective actions required before entering the storage area. Warning signs and notices shall be posted in accordance with CFR 29 Part 1926, Section 62.

One centralized storage site may be used to store waste materials from structures at adjacent projects provided that transport of waste over roads open to the public is not required and that the materials shall be labeled and stored separately. If a centralized storage location is used, suitable security fencing shall be installed around the perimeter of the centralized storage area to prevent unauthorized access. The Contractor shall establish this site, with Department approval, prior to beginning any coating removal.

The site for the temporary storage of the waste material shall be approved by the Engineer and shall not be located within a flood plain or drainage area or where water will pond. Containers of waste material shall have tops secured and be covered with waterproof coverings, and the site shall be secured. If such a site is not available immediately adjacent to the structure, an alternate location on state property shall be used as approved by the Engineer and shall be submitted as a requested amendment to the Environmental Protection Plan. The Contractor shall be responsible to ensure that any over-the-road transport of hazardous waste complies with all local, state, or federal permitting, licensing, manifesting, and/or fee requirements.

(d) **Disposal:**

1. Solid waste material from a Type A structure or waste from a Type B structure that is determined by the Department not to be a hazardous waste shall be disposed of in a sanitary landfill Resource Conservation and Recovery Act (RCRA) Subtitle D or licensed industrial landfill that has a permit from the Virginia Department of Environmental Quality or an equivalent state or federal agency for out-of-state disposal facilities. The Contractor shall identify the landfill used by name, address, and permit number and shall certify that the waste material was properly disposed.
 2. Liquid waste from Type A and Type B structures that is determined by the Department not to be a hazardous waste shall be legally disposed of in a publicly owned treatment works facility (POTW). The Contractor shall identify the POTW used by name, address, and permit number and shall certify that the waste material was properly disposed.
 3. If waste material from a Type B structure is classified as hazardous, the Contractor shall obtain a provisional hazardous waste generator number from the Virginia Department of Environmental Quality in accordance with applicable federal and state regulations and shall legally store, pack, label, and ship such material by a transporter with an RCRA Hazardous Waste Transporter permit to a RCRA, Subtitle C, Treatment Storage and Disposal Facility (TSDF) for treatment and disposal. The Contractor shall prepare a hazardous waste shipping manifest(s) and provide it to the Engineer for signature. The Engineer's signature on the waste shipping manifest does not relieve the Contractor of his obligations as co-generator of the waste.
- (e) **Certifications:** The Environmental Plan shall be implemented in accordance with the provisions contained therein; any deviations from the plan shall be separately approved by the Engineer. The individual providing the plan certification shall at a minimum be present during startup and removal operations to ensure that the plan is fully implemented. Within 1 week following completion of the lead-based paint activities, the Contractor shall submit for the Engineer's record a written certification by the SSPC QP-2 Supervisor/Competent Person or CIH, including notations of any areas of non-compliance and corrective actions taken, that all work has been completed in full compliance with all applicable regulations and requirements as set forth in these specifications and that the plans on record were fully implemented. The Contractor shall forward for the Engineer's record one copy of the Environmental Plan complete with all revisions and results from the air monitoring activities, including notations of any areas of non-compliance and corrective actions taken.

411.09—Health and Safety

In accordance with the requirements of Section 107, the Contractor shall protect the health and safety of the workers, the public, and the environment from leaded paint or hazardous material resulting from coating preparation (cleaning) removal operations, blast abrasive, rust, and overspray.

- (a) **Plan:** The worker health and safety plan shall be in accordance with the requirements of the Virginia Occupational Safety and Health Administration, 29 CFR 1926.62 requirements and the applicable requirements of 29 CFR 1910.1025, and other applicable toxic metal standards, whichever is more restrictive.

The worker health and safety plan shall be approved by a CIH currently certified by the American Board of Industrial Hygiene or by an SSPC QP-2 Supervisor/Competent Person.

These plans shall not be submitted to the Engineer for approval but shall be submitted for the Engineer's review and record. After project award but not less than 3 weeks prior to commencing operations, the worker health and safety plan shall be submitted to the Engineer.

Within 2 weeks of receipt, the Engineer will review the submitted plan for completeness. Should deficiencies in the plan exist, the plan will be returned to the Contractor for incorporation of revisions as noted by the Engineer. The Contractor shall make such revisions and submit completed plans for the Engineer's record prior to commencing operations. In no case shall the Contractor begin work prior to the Engineer's receipt and review of a satisfactorily completed plan.

- (b) **Monitoring:** The CIH or SSPC QP-2 Supervisor/Competent Person providing plan approval or a qualified designated representative shall be present during startup, during surface preparation periods, and as needed during removal operations throughout the duration of the project to ensure the provisions of the worker safety and health plans are properly implemented.
- (c) **Certification:** At completion of the project, the CIH or SSPC QP-2 Supervisor/Competent Person shall submit a written statement of certification for the Engineer's record, complete with all revisions including notations of any areas of non-compliance and corrective actions taken, that the worker health plans fully complied with all regulations and that the plans were fully implemented.

411.10—Measurement and Payment

Coating of new metal on structures will not be measured for separate payment but shall be included in the price for structural steel or metal items. When a pay item, coating of new metal in or on structures will be paid for at the contract lump sum price per structure.

Prepare and spot coat existing structure, when a pay item, will be measured in square feet of surface area and will be paid for at the contract unit price per square foot.

Prepare and overcoat existing structure, when a pay item, will be paid for at the contract lump sum price per structure.

Recoat existing structure, when a pay item, will be paid for at the contract lump sum price per structure.

Zone coating of existing structure, when a pay item, will be paid for at the contract lump sum price per structure.

These prices shall include washing, surface preparation, and applying protective coating.

Environmental protection and health and safety will be paid for at the contract lump sum price per structure. This price shall include containment operation, regulation compliance, environmental protection plan preparation and approval, worker health and safety plan preparation and approval, providing CIH and SSPC QP-2 Supervisor/Competent Person monitoring services, worker protection, and all other related costs.

Disposal of material will be paid for at the contract lump sum price per structure. This price shall include transporting, storing, and disposal. No payment will be made for this item until the Contractor provides the signed return manifests from the disposal facility(s).

Payment will be made under:

Pay Item	Pay Unit
Coating of new metal on structures (B or Str. No.)	Lump sum
Prepare and spot coat existing structure (B or Str. No. and type)	Square foot
Zone coating of existing structure (B or Str. No. and type)	Lump sum
Prepare and overcoat existing structure (B or Str. No. and type)	Lump sum
Recoat existing structure (B or Str. No. and type)	Lump sum
Environmental protection and health and safety (B or Str. No.)	Lump sum
Disposal of material (B or Str. No. and type)	Lump sum

SECTION 412—WIDENING, REPAIRING, AND RECONSTRUCTING EXISTING STRUCTURES

412.01—Description

The Department will specify whether latex hydraulic cement concrete or silica fume hydraulic cement concrete will be used on bridge deck in the widening, repairing, or reconstruction of existing structures. The specific overlay deck material and the depth of the overlay will be shown in the contract documents.

412.02—Materials

- (a) **Epoxy and mineral fillers** shall conform to the requirements of Section 243. Epoxy for epoxy mortar shall be Type EP-5. Epoxy used for crack repair shall be Type EP-4 or EP-5, low viscosity.
- (b) **Hydraulic cement concrete and latex hydraulic cement concrete** shall conform to the requirements of Section 217, except that the coarse aggregate shall be size No. 7, No. 8, or No. 78 for depths and steel clearances less than 2 inches and shall be size No. 57, No. 7, No. 8, or No. 78 for depths more than 2 inches. The inclusion of fly ash or slag will not be permitted in concrete mixes used in bridge deck overlays or deck patching operations. An approved accelerator may be permitted when justified by traffic conditions.
- (c) **Reinforcing steel** shall conform to the requirements of Section 406.
- (d) **Accelerators** shall be noncorrosive and shall be approved by the Engineer.
- (e) **Materials for shotcrete** shall be as follows:

1. Portland and blended cements shall conform to the requirements of Section 214.
 2. Fly ash, slag, and silica fume shall conform to the requirements of Section 215.
 3. Water shall conform to the requirements of Section 216.
 4. Air-entraining admixtures shall conform to the requirements of Section 215.
 5. High-range and regular water reducers shall conform to the requirements of Section 215.
 6. Accelerators shall conform to the requirements of Section 215 but may be used only if approved by the Engineer. If used, they shall be added at the nozzle.
 7. Fine aggregates shall conform to the requirements of Section 202 for Grading A. Coarse aggregates shall conform to the requirements of Section 203 for size No. 8.
 8. Steel fibers shall have a minimum length of 3/4 inch and a diameter between 0.015 and 0.025 inch. They shall have bent or deformed ends or be continuously deformed throughout.
 9. Synthetic fibers shall have a minimum length of 3/4 inch and shall have demonstrated long-term resistance to deterioration in concrete.
- (f) **Welded wire fabric** shall conform to the requirements of Section 223 and shall be galvanized or epoxy coated.
- (g) **Expansion bolts** shall conform to the requirements of Section 226.02(d).

412.03—Procedures

Repairing concrete structures shall consist of removing and replacing deteriorated material, thoroughly cleaning exposed concrete surfaces and reinforcing steel, and replacing reinforcing steel. Cleaning shall be performed by sandblasting, waterblasting, or other approved methods to remove concrete, rust, oil, and other foreign materials detrimental to achieving a bond. The area and depth of repairs shall be as directed by the Engineer.

Dimensions of existing structures shown on the plans are approximate, and those that are pertinent to the construction of the new portion shall be verified in the field by the Contractor. Where details of new portions of the structure shown on the plans are not adaptable to the shape of the existing structure, practical modifications may be made during construction with the approval of the Engineer provided neither the existing nor the new portions are impaired in structural strength.

Areas to be repaired shall be outlined with saw cuts to a depth of at least 1 inch or to a depth that will clear the top of the reinforcing steel.

Loose and unsound materials shall be removed by the use of hand tools or pneumatic hammers weighing 30 pounds or less. Pneumatic hammers shall be worked at an angle of 45 to 60 degrees to the plane of the concrete surface being removed. The surface shall be sounded with a masonry hammer to determine the relative concrete strength.

When reinforcing bars are exposed, the exposed length shall be cleaned. Epoxy-coated steel shall not be cleaned by sandblasting. Damaged epoxy coating shall be repaired in accordance with the requirements of Section 243. Care shall be taken to prevent striking reinforcing bars with hammer points. Reinforcing steel that has lost 1/4 or more of its original cross-sectional area shall be lapped with new bars of the same size and shape. New bars shall lap existing bars a length of 30 diameters on each side of the damaged portion if a sufficient length of the existing bar is exposed. Otherwise, new bars shall be welded with a 6-inch arc-welded lap on each side of the damaged portion with a double-flare V-groove weld in accordance with the requirements of Section 407 or mechanically connected in accordance with the requirements of Section 406.

Dust and debris shall be removed by blowing with compressed air or hosing with water. A fine spray of moisture shall be applied to the surface to outline, as it evaporates, loose fragments that are locked in place. Just prior to placement of repair material, the surface shall be cleaned.

Unsupported areas shall be supported with forms.

Excess material and debris resulting from repairs shall be removed and disposed of in an approved disposal area in accordance with the requirements of Section 106.04.

Wherever concrete is placed against existing concrete, dowels at least 3/4 inch in diameter shall be placed at no more than 2 feet 6 inches center to center over the entire jointing surface and 6 to 12 inches from the edge. Dowels shall be placed perpendicular to the surface of existing concrete by drilling and grouting and shall project into both new concrete and existing concrete to a depth as great as the thickness of the concrete will allow but need not project more than 9 inches.

For footings and neat work of substructures where joining planes are vertical, 3/4-inch headed expansion bolts shall be used instead of dowels. Bolts shall project at least 9 inches into new concrete and shall extend sufficiently far into existing concrete to develop their rated pullout strength but not less than 6 inches. When drilling holes for expansion bolts, care shall be taken so that existing reinforcing steel is not damaged.

Where necessary to prevent feathered edges, existing concrete shall be removed to ensure a thickness for new concrete of at least 6 inches.

Concrete shall be constructed in accordance with the requirements of Section 404 except that surfaces shall be finished to match the existing adjacent surfaces. Superstructure concrete shall be Class A4, and substructure concrete shall be Class A3.

(a) **Bridge Superstructure Repairs:**

1. **Type A milling** shall consist of milling the surface of the bridge deck and concrete approaches to a depth of 1/2 inch.

Equipment shall be capable of removing material to the required depth while maintaining a reasonably uniform surface without damaging adjacent areas or the remaining material. Milling equipment shall be capable of removing at least 1/2 inch of existing material per pass. Power-driven hand tools for removing unsound concrete around reinforcing steel and in confined areas shall be required.

2. **Type A patching** shall consist of repairing the deck from the existing deck surface or milled surface to a depth that will not expose reinforcing steel.

3. **Type B patching** shall consist of repairing the deck from the existing deck surface or milled surface to a depth at least 1 inch below the top mat of reinforcing steel.
4. **Type C patching** shall consist of repairing the deck from the existing deck surface or milled surface to its full depth. Forms may be suspended from reinforcing steel by wire ties for areas of less than 3 square feet. In the case of larger area openings, forms shall be supported by blocking. Sound concrete shall be removed to obtain a somewhat vertically shaped surface at the edges of the patch.
5. **Epoxy-mortar patching** shall be performed in accordance with the requirements for Type A patching and to a depth up to and including 3/4 inch. Proportions of sand and epoxy shall be approved by the Engineer. Surface areas to be patched shall be dry and primed with neat epoxy just prior to mortar placement. Mortar may be troweled in place to feathered edges. The patched surface shall be sprinkled with sand before the epoxy sets or sandblasted just prior to placement of the seal to ensure bonding. When epoxy mortar is to be the finished riding surface, patches exceeding 8 feet in a longitudinal direction shall be tested in that direction in accordance with the requirements of Section 404.04.
6. **Crack repairs** shall be performed as follows: Structural cracks and dormant cracks shall be V-grooved to a depth of approximately 1/2 inch and blown clean. The groove shall be filled with neat epoxy. At the Contractor's option, latex concrete may be brushed into the groove in lieu of epoxy when latex concrete is monolithically placed for Type A, B, or C patching or joint repairs.
7. **Concrete superstructure surface repair** shall include repairing raised medians, median barriers, beams, diaphragms, parapets, posts, rails, curbs, and sidewalks. Superstructure surface repair shall be performed in accordance with the requirements for Type B patching.

When the thickness of the surface repair is 2 inches or more, 2 x 2-W1.4 x W1.4 welded wire fabric shall be used. The fabric shall be tied to reinforcing steel where possible. If reinforcing steel is not exposed or if the steel has a spacing greater than 1 foot 6 inches, expansion bolts 3/8 inch in diameter shall be placed and the fabric tied to the bolts. The expansion bolts shall be spaced not more than 1 foot 6 inches apart and shall be embedded at least 2 inches into the concrete. The minimum thickness of Class A and Class B shotcrete over reinforcing steel, including expansion bolts and welded wire fabrics, shall be 2 inches except in transition areas where shotcrete is feathered to existing concrete with less than 2 inches of cover or where patches are made on existing concrete with less than 2 inches of cover. Where shotcrete containing silica fume is used, the minimum cover over reinforcing steel shall be 1 1/2 inches.

8. **Joint opening repairs** shall be performed as follows: Expansion joint removal shall consist of removing and disposing of concrete, repairing and replacing reinforcing steel, and cleaning exposed surfaces.

Expansion joint reconstruction shall consist of removing and disposing of concrete, repairing and replacing reinforcing steel, cleaning exposed surfaces, and recasting the joint to the limits detailed with hydraulic cement concrete.

When not included in other joint repairs, saw cutting of the joint shall consist of saw cutting concrete to the limits detailed.

9. **Joint resealing of existing joints** shall be performed in accordance with the requirements of Section 316 unless otherwise specified on the plans.
- (b) **Bridge Deck Overlay Repairs:** Overlays shall not be placed until deck repair concrete has attained 93 percent of the minimum design compressive strength. Vehicular traffic will not be permitted on the bridge until the overlay has attained a compressive strength of 3,500 pounds per square inch.

Expansion joints and dams shall be maintained through the overlay. A bulkhead equal in thickness to the width of the joint shall be installed to the required grade and profile prior to concrete placement.

A construction dam or bulkhead shall be installed in the case of a major delay in placement operations. During minor delays of 1 hour or less, the end of the placement shall be protected from drying.

1. **Latex or Silica Fume:** Within 24 hours immediately preceding the beginning of the overlay operations, the entire surface to be overlaid and the edge of previously placed overlay shall be thoroughly cleaned. This shall include the widened portion of bridge decks that are specified to be overlaid with latex or silica fume concrete.

For at least 1 hour prior to placement of overlay concrete, the surface shall be continuously and thoroughly water soaked. Puddles of standing water shall be removed before the overlay is placed.

The overlay shall be placed only when the ambient air temperature is 50 degrees F and rising. At temperatures above 85 degrees F, the Engineer may require placement to be made at night or during early morning hours if a satisfactory surface finish is not being achieved.

Mixers for latex hydraulic cement concrete shall be batch mixers or automatic mobile continuous mixers conforming to the requirements of Section 217. The mixing capacity shall be such that placing and finishing operations can proceed at a uniform rate, with final finishing completed before formation of the plastic surface film. A yield test shall be performed by the Contractor prior to deck placement for each mixing unit, when each unit is moved from the job site for recharging, when the source of stock-piled materials is changed and when there is reason to believe that the calibration may be erroneous. Mixers for silica fume concrete shall be truck mixers conforming to the requirements of Section 217. The amount mixed shall be such that the placing and finishing operations can proceed at a uniform rate. The latex concrete shall be uniform in composition and consistency when discharged from the mixer.

The overlay shall have a thickness of at least 1 1/4 inches of latex or silica fume hydraulic cement concrete. At the Contractor's option, latex or silica fume concrete may be used in lieu of hydraulic cement concrete as required for Type A, B, or C patching or joint and crack repairs, and such material shall be placed monolithically with the overlay.

Prior to placement of the overlay, a portion of the latex or silica fume concrete shall be brushed onto the prepared surface. Care shall be taken to ensure that both vertical and horizontal surfaces receive a thorough even coating and that the rate of progress is limited so that the brushed material does not become dry before it is covered with additional material and brought to final grade. Excess coarse aggregate remaining after brushing shall be removed.

If the rate of evaporation of surface moisture from the latex-modified or the silica fume concrete exceeds 0.05 pound per square foot per hour during placement, measures shall be taken to reduce the rate of evaporation. One effective method is to increase the relative humidity near the surface by fogging.

The surface shall be protected from drying or cracking by prompt application of wet burlap. Care shall be taken to ensure that the burlap is well drained and that it is placed as soon as the surface will support it without deformation. The burlap and surface of the concrete shall be maintained in a continuously moist condition during the initial curing period. For the latex concrete, the initial moist curing period shall be 48 hours, unless otherwise specified, followed by an additional 48 hours of air curing before opening to traffic. For the silica fume concrete, the initial moist curing period shall be 72 hours, unless otherwise specified, followed by the immediate application of a liquid membrane-forming curing compound conforming to the requirements of Section 220. The curing compound shall be completely dry before opening the overlay to traffic.

2. **Polymer:** Polymer overlays shall be placed in accordance with the applicable special provisions.
- (c) **Removing Asphalt Concrete Overlay:** Removal of the asphalt wearing surface from bridge decks and approach slabs shall be performed in a manner such that underlying sound concrete can be prepared to receive necessary treatment. The asphalt material shall be disposed of in an approved manner. Sound concrete damaged as a result of the Contractor's operations shall be repaired in accordance with the requirements of (a) herein at the Contractor's expense. Fuel oils or other materials that will prevent subsequent treatments from bonding to remaining concrete shall not be used.
 - (d) **Bridge Substructure Repairs:** Concrete substructure surface repair shall include repairing piers, wing blocks, and abutments. Substructure surface repair shall be performed in accordance with the requirements for Type B patching. Removal of concrete shall be to a depth as specified on the plans or as directed by the Engineer. Welded wire fabric shall be installed in accordance with the requirements of (a)7. herein.
 - (e) **Blocking and Jacking Beams:** The Contractor shall submit to the Engineer for approval his method of jacking and blocking beams to repair beam seats. Unless approved by the Engineer in writing, structures supported on jacks shall not be subjected to traffic loadings.
 - (f) **Shotcrete:** When specified for repairs or approved in lieu of hydraulic cement concrete, shotcrete repairs shall be performed in accordance with the requirements of (a)7 and (d) herein.
 1. **Classes of Shotcrete and Mixture Proportions:** Two classes of shotcrete are established. The minimum amount of cementitious material shall be 658 pounds per cubic

yard for Class A and 635 pounds per cubic yard for Class B. The classes are as follows:

- a. **Class A:** Class A shotcrete shall be reinforced by either steel or synthetic fibers as specified on the plans and shall have a minimum compressive strength at 28 days of 5,000 pounds per square inch. When steel fibers are used, the minimum fiber content shall be 60 pounds per cubic yard. When synthetic fibers are used, the minimum fiber content shall be 6 3/4 pounds per cubic yard. Shotcrete shall also contain silica fume at a minimum of 7 percent by mass of the cementitious material. Use of fly ash (maximum 20 percent by mass of the cementitious material) or slag (maximum 50 percent by mass of the cementitious material) will be permitted. The minimum thickness of Class A shotcrete cover over reinforcing steel shall be 2 inches except in transition areas where shotcrete is feathered to existing concrete with less than 2 inches of cover or where patches are made on existing concrete with less than 2 inches of cover over reinforcing steel.
- b. **Class B:** Class B shotcrete shall have a minimum 28-day compressive strength of 4,000 pounds per square inch. The cementitious material shall be either all portland cement; portland cement and fly ash (maximum 20 percent by mass of the cementitious material); portland cement and slag (maximum 50 percent by mass of the cementitious material); or portland cement and silica fume (minimum 7 percent by mass of the cementitious material). The minimum thickness of Class B shotcrete cover over reinforcing steel shall be 2 inches except in transition areas where shotcrete is feathered to existing concrete with less than 2 inches of cover or where patches are made on existing concrete with less than 2 inches of cover over reinforcing steel. Where shotcrete containing silica fume is used, the minimum cover over reinforcing steel shall be 1 1/2 inches.

The Contractor shall submit for the Engineer's approval shotcrete mixture proportions and performance test data for each class of shotcrete based on the materials to be used in the project. If appropriate recent test data do not exist, the Contractor shall prepare trial mixtures and submit the test results as obtained from tests specified in Section 412.03(f)7.

Wet Process: Shotcrete subject to freezing and thawing shall have an air content of 7.0 percent \pm 1.5 percent as delivered to the job site. The materials for wet process shotcrete shall be mixed in accordance with the requirements of Section 217 and applied within 90 minutes after batching.

Dry Process: Solid ingredients for dry-mix shotcrete shall be predampened as needed and mixed in a batch type or continuous mixer. Most of the mixing water shall be added at the nozzle. Dry-mix shotcrete material shall be applied within 45 minutes after batching or predampening.

2. Equipment and Personnel:

- a. **Equipment:** Shotcrete delivery equipment shall be approved by the Engineer before the commencement of the work. It shall be capable of discharging the shotcrete mixture in a continuously smooth stream of uniformly mixed ingredients. Air added at the nozzle shall be free from oil or other contaminants, and the air

pressure shall be capable of maintaining sufficient nozzle velocity to all parts of the work.

- b. **Personnel:** Nozzlemen with at least 100 hours of recent similar shotcrete application experience and supervisors with at least 3 years of recent similar shotcreting experience who can provide references showing satisfactory performance on at least three similar jobs may be approved as being qualified without gunning pre-qualifying panels.

When proposed nozzlemen do not have the required experience or when the Engineer deems the work to be done of a sufficiently critical nature to require prequalifying tests for nozzlemen, approval will be based on test panels as described herein prior to the commencement of the work. The Engineer will observe the gunning of such test panels and judge the qualifications of the nozzleman on the basis of the texture, uniformity of work, and adequacy of the encasement of shotcrete around the reinforcement.

3. **Surface Preparation:**

- a. The perimeter of all areas where concrete is removed shall be tapered at approximately a 45-degree angle except that the outer edges of all areas removed by chipping shall be saw cut perpendicular to the surface to a minimum depth of 1/2 inch to prevent featheredging unless otherwise approved by the Engineer.
- b. Earth surfaces shall be trimmed to line and grade and shall have adequate support to prevent displacement during shotcrete placement. Shotcrete shall not be placed on an earth surface that is frozen, spongy, or subject to free running water at the time of the application of shotcrete. Active seeps, drips, and flowing water shall be controlled by installation of suitable drain systems such that water pressure does not build behind shotcrete linings. The Contractor shall prevent excessive loss of mixing water from the shotcrete. This shall be accomplished by one of the following procedures:
 - (1) Wet the soil prior to the time of gunning to the extent that it is damp but with no visible free water on the surface. Puddling, ponding, or freestanding water shall be eliminated from areas to be shotcreted.
 - (2) As an alternative or when specified, install a moisture barrier system to inhibit the movement of moisture from the newly placed shotcrete into the earth. Wrinkling and folding of moisture barrier shall not be permitted.
- c. Rock surfaces shall be free of loose material, debris, chips, mud, dirt, and other foreign matter. Surfaces shall be damp at the time of gunning, but puddling, ponding, or freestanding water shall not be permitted.
- d. Wood forms that are to be removed after use shall have a form release agent applied to prevent the absorption of moisture and inhibit the bond between shotcrete and the form.

4. **Application:**

- a. When applied, shotcrete shall have a temperature of at least 50 degrees F but not more than 85 degrees F. The ambient and surface temperature shall be 50 degrees F and rising. At ambient air temperatures above 85 degrees F, the Engineer may require placement to be made at night or during early morning hours.
 - b. Shotcrete to be applied to uneven and previously repaired surfaces shall first be applied to any deep hole, deeply excavated sections, corners, or areas where rebound cannot escape or be blown free. The thickness of the shotcrete layer shall be such that no sloughing, sagging, tearing, or debonding will occur. Existing concrete shall be sandblasted within 24 hours of application, and the surface shall be damp just prior to application.
 - c. Where a layer of shotcrete is to be covered by a succeeding layer, it shall be first allowed to develop its initial set. Then, loose, uneven, or excess material, glaze and rebound shall be removed by brooming, scraping, or other means. Any surface deposits that take a final set shall be removed by sandblasting, and the surface cleaned with an air-water blast from the nozzle. Curing compounds shall not be applied to surfaces that will be covered by an additional layer of shotcrete.
 - d. Shooting wires, ground wires, or other devices acceptable to the Engineer shall be used to control the line, grade, and thickness of the shotcrete.
 - e. During the shotcrete application, the nozzle shall be held perpendicular to and, when possible, 3 to 5 feet away from the receiving surface and rotated steadily in series of small oval or circular patterns. Whenever possible, sections shall be gunned in one layer to the full design thickness. However, for multiple layers of reinforcement, gunning of one layer of shotcrete may be required for each layer of reinforcement.
 - f. When encasing reinforcement, the nozzle shall be held closer than normal and at a slight upward angle. The mixture may be wetter than normal but not so wet that sloughing behind the reinforcement will occur.
 - g. Vertical surfaces shall be gunned starting at the bottom. Rebound or previously expended material shall not be incorporated in the applied layer, and all such material shall be removed from the surface and work area prior to final set and before placement of shotcrete on adjacent surfaces. Shotcrete shall not be placed if drying or stiffening of the mixture is occurring.
5. **Finishing:** Prior to the initial set, the shotcrete surface shall be scraped or cut with a trowel or metal template to obtain an even and aesthetically acceptable appearance. The final finishing shall be with a wet sponge unless otherwise specified. Trowel or float smoothing will not be allowed.
 6. **Curing:** After gunning, the surfaces of shotcrete shall be protected from drying or cracking. When necessary, fogging shall be used prior to the application of moist curing or a curing compound. Shotcrete shall be moist cured for a period of at least 7 days or cured using a curing compound conforming to the requirements of Section 220. The rate of application shall be not less than 1 gallon of curing compound per 100 square feet of surface. The color of the curing compound shall be approximately that of the existing concrete.

7. Quality Assurance and Testing:

- a. Preconstruction testing may be waived by the Engineer if it can be shown that the crew to be used is qualified and that the mixture has been successfully used in similar work.

Test panels 24 inches by 24 inches by 4 inches deep containing steel reinforcement representative of that to be used on the project shall be prepared. Each crew shall gun two test panels with the mix design to be used on the project and for each gunning orientation to be encountered on the job. Panels shall be cured in the field in the same manner as the structure for 1 day and transported to the laboratory, where curing shall be continued until the time of testing. For shotcrete jobs of less than 200 square feet, the Contractor shall cut one of the test panels with a trowel or a metal template before the initial set in the presence of the Engineer to check visually for possible voids under the reinforcement. For larger jobs where specific evidence of good encasement of reinforcing bars is needed, the Contractor shall cut cores from the test panels after the concrete has hardened for at least 3 days. Cores shall be cut through the steel.

The second panels for all jobs shall be used to determine the compressive strength of the applied shotcrete. Cores shall be 2 inches to 4 inches in diameter and shall be taken between the reinforcement. The cores will be tested by the Department at the specified age in accordance with the requirements of ASTM C42.

- b. In-place shotcrete shall be of uniform quality and free from segregation, honeycombing, sand pockets, sand lenses, sagging, dry patches, overspray, rebound, or incomplete encasement of reinforcement. It shall also be free from delamination, cracking, or single voids with dimensions in excess of 1/4 inch.

The Department reserves the right to test any section and reject shotcrete that does not conform to the specification requirements in terms of test values, soundings, and visual examination. The cost of any additional testing of disputed shotcrete that results in rejection shall be borne by the Contractor.

The Contractor shall remove and replace or correct defective shotcrete to the satisfaction of the Engineer.

- c. For compressive strength tests, one test panel shall be prepared for each day's production or for each 200 square feet of shotcreting by each crew using the same ingredients and gunning orientation as the shotcrete applied to the job. These panels shall be cured and delivered to the designated testing laboratory as specified earlier in this section.

Test values on such panels shall equal or exceed the required 28-day strength requirements. Should failures occur, acceptance of the material will be determined by tests on cores from the applied work. A minimum of three cores shall be taken from the area in question. The average compressive strength of the cores taken from the work shall equal or exceed the specified strength for the class of shotcrete applied, and no single core shall have a strength less than 85 percent of the specified value. If deemed necessary by the Engineer, the adequacy of the bond between the existing concrete and the shotcrete shall be determined by pull-off

tests in accordance with the requirements of ACI 503. A minimum bond strength of 250 pounds per square inch will be accepted as satisfactory. Bond failure at less than 250 pounds per square inch attributable to the failure of existing concrete will not be cause for rejection. The cost of up to three pull-off tests shall be the responsibility of the Contractor; additional pull-off tests will be the responsibility of the Department.

412.04—Measurement and Payment

Volumes outlined by the completed excavation, formwork, and surfaces of the existing concrete will be measured prior to concrete placement so that quantities can be accurately computed.

Hydraulic cement concrete for the class specified will be measured and paid for in accordance with the requirements of Section 404.

Type A milling will be measured and paid for in square yards for the depth specified.

Types A, B, and C patching and concrete substructure or superstructure surface repair will be measured in square yards of surface area and will be paid for at the contract unit price per square yard. This price shall include furnishing and placing concrete to fill the prepared areas.

Epoxy-mortar patching will be measured in gallons of epoxy-mixed system used as a binder for mortar in place and for priming prior to application of epoxy mortar and will be paid for at the contract unit price per gallon.

Expansion joint removal, expansion joint reconstruction, and backwall reconstruction will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include furnishing and placing concrete to fill the prepared areas for expansion joint reconstruction and backwall reconstruction.

Saw cutting, when a pay item, will be measured in linear feet of concrete sawed and will be paid for at the contract unit price per linear foot.

Jacking and blocking of beams as required to complete beam seat repair, when a pay item, will be paid for on an each basis per beam end.

Latex hydraulic cement concrete will be measured and paid for at the contract unit price per square yard on a plan quantity basis. The price bid will be full compensation for producing the latex hydraulic cement concrete mix, delivering it to the job site, and placing it at the job site. This price shall also include handling, finishing, and curing the latex hydraulic cement concrete and all material, labor, tools, equipment, and incidentals necessary to complete the work. Latex hydraulic cement concrete shall be placed within the range of depth specified and verified by the Engineer prior to and during placement operations. The Engineer may direct additional depth of latex hydraulic cement concrete to address cross slope and other surface irregularities and rideability issues. Additional latex hydraulic cement concrete beyond the depth range of the pay item that is requested to address such issues at the direction of the Engineer will be compensated for in accordance with the provisions of Sections 104.02 and 109.05. Only those volumes of additional latex hydraulic cement concrete that are approved by the Engineer prior to or during the placement of the overlay will be considered for payment. Payment will be made for the actual cost only for furnishing the mixture to the job site.

Silica fume hydraulic cement concrete will be measured and paid for at the contract unit price per square yard on a plan quantity basis. The price bid will be full compensation for furnishing silica fume hydraulic cement concrete; placing, handling, finishing, and curing the silica fume hydraulic cement concrete; and for all material, labor, tools, equipment, and incidentals necessary to complete the work. Silica fume hydraulic cement concrete shall be placed within the range of depth specified and verified by the Engineer prior to and during placement operations. The Engineer may direct additional depth of silica fume hydraulic cement concrete to address cross slope and other surface irregularities and rideability issues. Additional silica fume hydraulic cement concrete beyond the depth range of the pay item that is requested to address such issues at the direction of the Engineer will be compensated for in accordance with the provisions of Sections 104.02 and 109.05. Only those volumes of additional silica fume hydraulic cement concrete that are approved by the Engineer prior to or during the placement of the overlay will be considered for payment. Payment will be made for the actual cost only for furnishing the mixture to the job site.

Crack repair will be measured in linear feet and will be paid for at the contract unit price per linear foot.

Removal of asphalt concrete overlay will be measured in square yards of surface area and will be paid for at the contract unit price per square yard.

Shotcrete, when specified as a pay item, will be measured in square feet of surface to which it is applied and will be paid for at the contract unit price per square foot or per cubic foot for the type specified.

These prices shall include cutting, drilling, hammering, and all other work involved in the complete removal and disposal of concrete and other materials necessary to provide for joining the new and old portions of the structure in accordance with the plans or as directed by the Engineer. The contract unit price shall also include dowels or other approved anchoring devices, disposing of surplus material, cleaning and repairing reinforcing steel, and welded wire fabric if necessary. If Class A shotcrete is used, the price shall also include steel or synthetic fibers.

Payment will be made under:

Pay Item	Pay Unit
Type A milling (Depth)	Square yard
Type A patching	Square yard
Type B patching	Square yard
Type C patching	Square yard
Epoxy-mortar patching	Gallon
Concrete substructure surface repair	Square yard
Concrete superstructure surface repair	Square yard
Expansion joint removal	Linear foot
Expansion joint reconstruction	Linear foot
Back wall reconstruction	Linear foot
Saw cutting	Linear foot
Jacking and blocking	Each
Latex hydraulic cement concrete (1 1/4 inches to 1 3/4 inches)	Square yard
Silica fume hydraulic cement concrete (1 1/4 inches to 1 3/4 inches)	Square yard

Pay Item	Pay Unit
Crack repair	Linear foot
Removal of asphalt concrete overlay	Square yard
Pneumatically applied mortar	Square foot
Shotcrete (Class ____)	Square foot or cubic foot

SECTION 413—DISMANTLING AND REMOVING EXISTING STRUCTURES OR REMOVING PORTIONS OF EXISTING STRUCTURES

413.01—Description

This work shall consist of dismantling and removing all or portions of existing structures in accordance with these specifications and in conformity with the lines, grades, and details shown on the plans or as established by the Engineer. The Contractor shall make all necessary notifications, including, but not limited to, the National Emission Standards for Hazardous Air Pollutants (NESHAPs) demolition/renovation notification to the Virginia Department of Labor and Industry, amended notifications, and obtain any necessary permits in accordance with all applicable local, state, and federal laws and regulations. The Contractor shall protect the public and the environment from leaded paint or other hazardous material encountered in the work.

413.02—Procedures

- (a) **Dismantling and Removing Existing Structure:** Dismantling and removing existing structures shall include removing the entire superstructure, substructure, and slope protection. The substructure shall be removed down to the streambed or to an elevation of at least 2 feet below the natural ground or finished grade of embankment that is to remain in place. Removal shall include any part of the substructure or foundation piling that will interfere with the new construction. For bridges crossing streams under the jurisdiction of the U.S. Coast Guard, the substructure shall be removed to or below the bed of the stream as required by the U.S. Coast Guard.
1. **Dismantling structures for retention by the Contractor:** Removed materials shall become the property of the Contractor and shall be removed from the project. The Contractor shall assume all personal and property liability associated with such materials and shall protect and save harmless the Department from any and all damages and claims associated with the handling, transportation, storage, or use of such materials. The Department does not warrant the condition or the physical or chemical characteristics of the materials.
 2. **Dismantling structures for retention by the Department:** Dismantling shall be in accordance with a method approved by the Engineer and shall be such as to preserve the existing condition of materials.

Units shall be match marked for re-erection according to an approved diagram provided by the Department.

Material shall be stored as directed within 1/2 mile of the site of the existing structure.

- (b) **Removing Portion of Existing Structure:** The portions to be removed shall be the areas designated on the plans. No portion of the structure shall be removed by blasting or other methods that may damage any portion of the structure that will remain in place. When pneumatic hammers are used to remove concrete, their weight shall be not more than 90 pounds for widening work or 30 pounds for deck repair work. The use of tractor-mounted demolition hammers with a maximum manufacturer's rated striking energy of 1,000 foot-pounds will be permitted for the removal of concrete parapets down to the top of deck and for that portion of the deck where the reinforcing steel will be removed. The use of tractor-mounted demolition hammers or pneumatic hammers weighing more than 30 pounds shall not be allowed for the removal of that portion of the deck that is within 6 inches of the top flange of the beams/girders to remain in the structure. With the written approval of the Engineer, hydraulically actuated, jaw type, concrete crushers may be used for the removal of concrete parapets down to the top of the deck. The approval of hydraulically actuated, jaw type, concrete crushers shall be contingent upon continuous satisfactory results with no damage to any portion of the structure that is to remain in place. The removal of concrete parapet on prestressed concrete slab spans or prestressed concrete box beam spans shall be limited to 30-pound pneumatic hammers within 2 inches of the deck and not more than 90-pound pneumatic hammers for the remainder of the parapet unless otherwise approved by the Engineer.

Disturbed areas shall be uniformly graded to natural ground contours in a manner that will facilitate drainage and prevent impoundment of water.

Materials or portions of existing structures removed shall be handled in accordance with the requirements of (a)1. herein.

- (c) **Environmental and Worker Protection:** Heating, welding, flame cutting, grinding, chipping, needle gun cleaning, manual scraping, heat gun cleaning, drilling, straightening, and other construction operations, or demolition of Type B structures, as defined in Section 411.01(b), that disturbs areas coated with a hazardous material shall require environmental and worker protection.
1. **Environmental protection** shall be in accordance with the requirements of Section 411.08 except that work involving the removal of 100 square feet or less of protective coating from a Type B structure will not require the Contractor to submit and implement an environmental plan as specified in Sections 411.08(a) and 411.08(b). However, the Contractor shall comply with appropriate local, state, and federal codes and regulations and shall employ appropriate measures to prevent the release of hazardous materials in the environment. Determination of the total square footage of removal area shall not include the cumulative area of coating disturbance from removal of bolts. Hazardous materials generated from the Contractor's operation shall be disposed of in accordance with the requirements of Sections 411.08(c) and 411.08(d).
 2. **Worker health and safety protection** shall be in accordance with the requirements of Section 411.09 except that work involving the removal of 100 square feet or less of protective coating from a Type B structure will not require the Contractor to submit and implement a worker health and safety plan as specified in Sections 411.09(a) and 411.09(b). However, the Contractor shall comply with applicable codes and regulations regarding public and worker health and safety.

Upon completion of the project, the Contractor shall submit a written statement of certification for the Engineer’s record, complete with all revisions including notations of any areas of non-compliance and corrective actions taken, that certifies both the Environmental Protection Plan and the Worker Health and Safety Plan were fully implemented during the performance of the work covered by this specification.

413.03—Measurement and Payment

Dismantling and removing an existing structure will be paid for at the contract lump sum price.

Removing a portion of an existing structure will be paid for at the contract lump sum price.

Environmental and worker protection, when a pay item, will be paid for at the contract lump sum price per structure. This price shall include containment operations, regulation compliance, plan approval services, worker protection, and other related costs.

Material disposal, when a pay item, will be paid for at the contract lump sum price per structure. This price shall include transporting, storing, and legal disposal of material.

If not shown as a pay item, the cost for worker and environmental protection and material disposal shall be included in other appropriate bid items.

Payment will be made under:

Pay Item	Pay Unit
Dismantle and remove existing structure (B or Str. No.)	Lump sum
Remove portion of existing structure (B or Str. No.)	Lump sum
Environmental and worker protection (B or Str. No.)	Lump sum
Material Disposal (B or Str. No. and type)	Lump sum

SECTION 414—RIPRAP

414.01—Description

This work shall consist of placing the specified type of riprap in accordance with the plans, Standard Drawings where applicable, and these specifications.

414.02—Materials

- (a) **Riprap** shall conform to the requirements of Section 204.
- (b) **Sand** shall conform to the requirements of Section 202. Grading A, B, or C sand may be used in mortared or grouted riprap.
- (c) **Mortar and grout** shall conform to the requirements of Section 218.

- (d) **Geotextile bedding** shall conform to the requirements of Section 245.
- (e) **Welded wire fabric** shall conform to the requirements of Section 223.

414.03—Procedures

- (a) **Dry Riprap:** The classes of dry riprap shall be as follows:
 1. **Class I:** Stones shall weigh between 50 and 150 pounds each. At least 60 percent shall weigh more than 100 pounds, and approximately 10 percent may weigh 50 pounds or less.
 2. **Class II:** Stones shall weigh between 150 pounds to 500 pounds each. At least 50 percent shall weigh more than 300 pounds, and approximately 10 percent may weigh 150 pounds or less.
 3. **Class III:** Stones shall weigh from 500 pounds to 1,500 pounds each. At least 50 percent shall weigh more than 900 pounds, and approximately 10 percent may weigh less than 500 pounds.
 4. **Class AI:** Stones shall weigh between 25 and 75 pounds each, except that approximately 10 percent may weigh 25 pounds or less and 10 percent may weigh 75 to 100 pounds.

Dry riprap shall be placed as follows:

Grading: Slopes shall be finished to a reasonably smooth and compact surface within a tolerance of 6 inches from the surface lines shown on the plans.

Immediately prior to placement of riprap bedding, the prepared base will be inspected. Riprap or bedding shall not be placed until the prepared base has been approved.

Bedding: Riprap bedding shall be placed on the embankment to form a backing for riprap. Riprap bedding shall be spread uniformly on the prepared base. Compaction of the bedding material will not be required, but material shall be finished to a reasonably even surface, free from mounds or depressions.

When geotextile bedding material is required, the entire perimeter of the material shall be turned down and buried at least 9 inches for anchorage. Adjacent strips of material shall run only up and down the slope and shall overlap at least 18 inches. Geotextile bedding material shall not be used on slopes greater than 1:1. If sewed, strips shall overlap at least 4 inches and shall be double stitched with a prayer seam, Type SSa 1. Damaged material shall be replaced or repaired with a patch of the same material overlapping the damaged area by at least 18 inches on all sides. Displaced material shall be repositioned, including, if necessary, removing and replacing riprap stone, at the Contractor's expense. Material shall be placed loosely so that positioning riprap will not stretch or tear it.

Placing stones: Riprap shall be placed on the embankment as soon as practicable after bedding has been finished but no later than 15 days in a manner that will produce a

reasonably well-graded mass of rock with the minimum practicable percentage of voids. Riprap shall be placed to its full course thickness in one operation and in a manner to avoid displacing underlying material. Riprap stone shall not be dropped onto fabric from a height greater than 1 foot. Smaller-sized material shall not be dropped onto fabric from a height greater than 3 feet. Larger stones shall be reasonably well distributed.

Finished riprap shall be free from objectionable pockets of small stones and clusters of larger stones. Hand placing may be required to the extent necessary to secure the results specified and form uniform slopes.

A tolerance of $\pm 1/4$ of the thickness of the maximum-size stone from the lines and grades shown on the plans will be allowed in the finished surface. However, the extremes of such tolerance shall be not continuous over an area of more than 200 square feet. Riprap shall be keyed into the natural ground in an approved manner and to a depth equal to the bed thickness or to solid rock.

The desired distribution of various sizes of stones throughout the mass may be obtained by selective loading at the source, controlled dumping of successive loads during final placement, or a combination of these methods. Placing riprap by dumping into chutes or similar methods likely to cause segregation of the various sizes will not be permitted.

Riprap protection shall be maintained until the riprap is accepted by the Engineer. Displaced material shall be replaced to the lines and grades shown on the plans at the Contractor's expense.

(b) **Dumped Riprap:** The types of dumped riprap shall be as follows:

1. **Type I:** Core riprap shall be composed of compact angular pieces of derrick stone weighing from 3/4 ton to 2 tons each with an average weight of approximately 1 ton. Approximately 10 percent by weight may weigh less than 3/4 ton.
2. **Type II:** Heavy riprap shall be composed of compact angular pieces of derrick stone weighing from 3 to 10 tons each with an average weight of approximately 4 tons. Approximately 10 percent by weight may weigh less than 3 tons.

Dumped riprap shall be placed in the same manner described for dry riprap in (a) herein. Dumped riprap shall not be placed in layers.

(c) **Mortared Riprap for Slopes:** Stone shall be the same size as specified for dry riprap, Class II, and shall be selected to secure fairly large, flat-surfaced stones that will produce a true and even surface with a minimum of voids. Stone shall be placed on a slope not steeper than the natural angle of repose of the fill material. Fifty percent of the mass shall be broad flat stones placed with the flat surface uppermost and parallel to the slope. Stones shall be placed first and roughly arranged in close contact, with the larger stones placed near the base of the slope. Spaces between larger stones shall be filled with stones of suitable size, leaving the surface reasonably smooth and tight and conforming to the contour required. Stones shall be placed in a manner so as to ensure for plane surfaces a maximum variation from a true plane of not more than 1 1/4 inches in 4 feet. Warped and curved surfaces shall have the same accuracy as specified for plane surfaces.

As each larger stone is placed, it shall be surrounded by fresh mortar, and adjacent stones shall be shoved into contact. After larger stones are in place, spaces or openings between them shall be filled with mortar, and smaller stones shall then be placed by shoving them into position, forcing excess mortar to the surface, ensuring that each stone is carefully and firmly bedded laterally.

After the work is complete, excess mortar forced up shall be spread uniformly to fill surface voids completely. Surface joints shall then be pointed roughly with flush or shallow smooth-raked joints.

- (d) **Grouted Riprap for Slopes:** Grout shall consist of 1 part hydraulic cement and 3 parts sand, thoroughly mixed with water to produce grout having a thick, creamy consistency.

Stones shall be of the same sizes and placed in the same manner as specified for dry riprap, Class I. Care shall be taken during placing to keep earth or sand from filling spaces between stones. After stones are in place, spaces between them shall be filled with grout from bottom to top and the surface swept with a stiff broom. Riprap shall not be grouted in freezing weather. In hot, dry weather, the work shall be protected from sunlight and kept moist for at least 3 days after grouting by the use of saturated burlap.

- (e) **Erosion Control Stone for Culvert Outlet Protection:** Erosion Control Stone for Class AI, I, & II culvert outlet protection shall conform to the requirements for Dry Rip Rap Class AI, I, & II respectively of (a) herein for weight and shall be placed in a manner to present an irregular or rough surface.

- (f) **Erosion Control Riprap:** Riprap shall consist of sound, nonerrodible shot rock or rock excavation, which may be obtained from within the excavation for the typical sections on the project. Erosion control riprap rock shall be not more than 15 inches in its greatest dimension and shall contain a sufficient percentage of smaller rocks to provide a reasonably dense mass with a thickness of at least 8 inches. Riprap shall be placed where shown on the plans or as directed by the Engineer in accordance with the requirements of Section 303.04(h).

- (g) **Concrete Riprap in Bags:**

1. **Wet mixture:** Riprap shall consist of Class C1 concrete in suitable burlap bags except in brackish or tidal water, where concrete shall be Class A3. Bags shall weigh approximately 100 pounds when 2/3 filled with concrete. Each bag shall be securely tied and immediately placed in the work. When used for foundation protection, bags shall be placed in accordance with the provisions governing placement of stone riprap for foundation protection as specified. When used for slope protection, riprap shall be placed in conformance with the provisions governing placement of dry riprap.
2. **Dry mixture:** Riprap shall conform generally to the requirements for wet mixtures except that the mixture shall consist of the dry ingredients and the requirements for water, consistency, and air will be waived.

Burlap or paper bags will be permitted. Riprap shall be a rectangular solid approximately 3 inches in thickness and shall weigh approximately 80 pounds per bag. Paper bags shall be perforated throughout on approximate 1-inch centers and shall be of adequate seal, thickness, and strength to maintain the integrity of the riprap until setting of

the concrete mixture. Bag compositions shall be such that bags will disintegrate without presenting environmental problems.

(h) **Stone Riprap for Foundation Protection:** Riprap for pier, abutment, and bridge spill slope protection shall conform to the requirements of the applicable specifications.

(i) **Concrete Slab Riprap for Stream Crossings:**

1. **Materials:** Riprap shall consist of Class A3 concrete, cast-in-place, 6 inches in thickness. Concrete shall have a consistency that will permit placement without the use of top forms.

Welded wire fabric shall be No. 6 gage wire, spaced 6 inches center to center.

2. **Excavation and fine grading:** The finished embankment slope shall be reasonably smooth and dense. A trench shall be dug at the toe of the slope to accommodate the toe of the slab. Slab riprap shall not be placed until the slope has been approved by the Engineer.
3. **Construction methods:** Riprap shall be constructed in accordance with the applicable requirements of Section 404 except as modified herein and shall be cured in accordance with the requirements of Section 316.04(j). Welded wire fabric shall be positioned at the center of the slab, shall run continuously throughout the slab, and shall lap approximately 6 inches at the edges of each sheet of fabric.

The berm portion of the slab shall be placed on a slope of approximately 12:1, draining away from the abutment. Where the edge of the slab is placed against the abutment, the joint shall be sealed to a depth of at least 1/2 inch with hot-poured joint sealer conforming to the requirements of Section 212.

The toe of the slab shall extend to an elevation at least 3 feet below the elevation of the toe of fill, and the lower edge of the slab shall be increased approximately 6 inches in thickness, tapering to its nominal thickness 3 feet up the slope from the lower edge of the slab. The tapering shall be on the underside of the slab. The slab shall be placed using one of the following methods:

- a. **Block method:** The slab shall be placed in alternate blocks approximately 4 feet by 4 feet.
- b. **Strip method:** The slab may be placed in alternate, continuous strips having scored or formed joints perpendicular to construction joints. Strips shall be placed in alternating widths of 4 feet and 5 feet, or 4 feet 6 inches each. Joints shall be at least 1 inch in depth and spaced approximately 4 feet 6 inches apart. The width of the joint shall be as small as possible.

Successive courses or strips shall not have joints that line up with the joints in the preceding courses or strips. Horizontal joints shall be normal to the slope. Joints shall be closed without filler.

After concrete is placed, it shall be consolidated and the surface struck off by means of a strike board. Concrete shall be float finished with a wooden or cork float. The surface shall not vary more than 1/2 inch under a 10-foot straightedge.

414.04—Measurement and Payment

Dry riprap will be measured in square yards of surface area or tons as specified.

Mortared riprap will be measured in square yards of surface area.

Grouted riprap will be measured in square yards of surface area or tons as specified.

Stone riprap for foundation protection will be measured in square yards of surface area or tons as specified.

Dumped riprap will be measured in square yards of surface area or tons as specified.

Concrete riprap in bags will be measured in cubic yards.

Concrete slab riprap will be measured in square yards. When an optional riprap is used in lieu of concrete slab riprap, bedding material will not be measured for payment and the riprap will be paid for at the contract unit price for concrete slab riprap.

Erosion control riprap will be measured in square yards of surface area or tons as specified.

Riprap will be paid for at the contract unit price. This price shall include furnishing and placing riprap, including welded wire fabric, mortar, or grout; excavation; and riprap bedding.

These prices shall include geotextile bedding material when required and when not a separate pay item for these purposes. The price bid shall include preparing the surface, furnishing and installing geotextile bedding material, overlaps, repair work, and excavating and backfilling toe-ins.

Erosion Control Stone used for Culvert Outlet Protection will be measured in square yards of surface area or tons for the class specified and will be paid for at the contract unit price per square yard or ton. This price shall include excavating, backfilling, preparing the surface, furnishing and installing geotextile bedding material including overlaps, repair work, excavating and backfilling toe-ins, and placing the required materials.

Payment will be made under:

Pay Item	Pay Unit
Dry riprap (Class and depth)	Square yard or ton
Mortared riprap (Depth)	Square yard
Grouted riprap (Depth)	Square yard or ton
Stone riprap (Depth)	Square yard or ton
Dumped riprap (Type and depth)	Square yard or ton
Concrete riprap in bags	Cubic yard
Concrete slab riprap	Square yard
Erosion control riprap (Depth)	Square yard or ton
Erosion control stone (Class, st'd)	Square yard or ton

SECTION 415—CONCRETE SLOPE PROTECTION

415.01—Description

This work shall consist of furnishing and installing precast concrete blocks in a bed of coarse sand or installing a concrete slab on embankments at or near bridge abutments as shown on the plans or as specified by the Engineer.

415.02—Materials

- (a) **Precast concrete blocks** shall conform to the requirements of Section 222.
- (b) **Mortar** shall be nonshrinking and shall conform to the applicable requirements of Section 218.
- (c) **Foundation course** shall be Grading B sand conforming to the requirements of Section 202 or approved local material similar in nature.
- (d) **Concrete** shall be Class A3 conforming to the requirements of Section 217.
- (e) **Welded wire fabric** shall be No. 6 gage, 6 inches center to center each way, conforming to the requirements of Section 223.
- (f) **Herbicide** shall conform to the requirements of Section 244.

415.03—Procedures

- (a) **Precast Concrete Block Slope Protection:** The subgrade shall be constructed at the required distance below the finished surface of the slope. Soft sections and unsuitable material shall be removed and replaced. The subgrade shall be compacted and shaped to a smooth, uniform surface.

The foundation course shall be spread on the subgrade to a depth of 2 inches and treated with an approved highly insoluble soil sterilant. Material shall be in a dry form and have a

maximum solubility rate of 250 parts per million. Material shall be uniformly applied at the maximum rate recommended by the manufacturer.

Blocks shall be bedded in the foundation course perpendicular to the finished surface in straight rows, with the longest dimension horizontal. Blocks shall be placed with continuous joints extending horizontally on the face of the slope and with broken (staggered) joints extending perpendicular thereto, up or down the slope. Blocks shall be rammed until the surface is firm and conforms to the finished slope. Joints shall be filled with mortar.

Cast-in-place edging for block slope protection shall be placed as specified in (b) herein.

- (b) **Concrete Slab Slope Protection:** The subgrade shall be prepared as for block slope protection. The cast-in-place concrete slab shall be 4 inches in thickness and shall be placed in accordance with the requirements of Section 414.03(i).

Except at railroad grade separations, the Contractor may provide a combination concrete slab and stone slope protection in lieu of the specified concrete slab slope protection. Protection shall be in accordance with the following:

1. Concrete portions, consisting of a paved ditch and a strip of concrete approximately 3 feet in width placed on the berm along the face of the abutment, shall be furnished as required for concrete slab slope protection. Stone shall be placed at a depth of 7 to 9 inches over the remaining area to be covered with slope protection.
2. The subgrade for concrete and stone shall be prepared in accordance with the requirements of Section 414.03(i). The portion of the slope to be protected with stone shall be treated with a herbicide in accordance with the requirements of (a) herein. Care shall be taken to confine application to areas designated for sterilization.
3. Stone shall be crushed gravel or stone conforming to the requirements of Section 205.02. Sizes furnished shall be not smaller than the sizes specified in Table II-5 for aggregate size No. 1, and the pieces shall be not larger than 8 inches in their greatest dimension. Stone shall be in a sufficient range of sizes to create a stable and reasonably uniform slope.

The condition of the subgrade and method of placing stone shall be such that pieces of stone in contact with the subgrade shall be partially embedded where practicable. Stone immediately adjacent to concrete shall not project more than 3 inches above the concrete.

Approved splash blocks connecting with the paved ditch shall be provided under downspouts draining onto the slope protection.

415.04—Measurement and Payment

Concrete slope protection will be measured in square yards of surface area and will be paid for at the contract unit price per square yard. If limits are not shown on the plans, measurements will be from the outside edge to outside edge, including curb, and from the edge of slope protection at abutment to the bottom of the curtain wall or outside edge of the paved ditch as appropriate. This price shall include the foundation course and treatment.

Payment will be made under:

Pay Item	Pay Unit
Concrete block slope protection	Square yard
Concrete slab slope protection (Depth)	Square yard

SECTION 416—WATERPROOFING

416.01—Description

This work shall consist of furnishing and applying waterproofing material on concrete bridge decks or other surfaces as shown on the plans.

416.02—Materials

- (a) **Epoxy-resin compounds and aggregates for surface application** shall conform to the requirements of Section 243. Epoxy resin shall be Type EP-5, low viscosity.
- (b) **Membrane and primer** shall conform to the requirements of Section 213.

416.03—Procedures

- (a) **Epoxy-resin:** Containers, tools, and mechanical equipment shall be free from solvents, loose material, and deposits of hardened material.

Epoxy resin shall not be applied when the concrete surface or the ambient air temperature is below 50 degrees F unless otherwise permitted by the manufacturer's instructions.

1. **Surface preparation:** Surfaces on which epoxy compounds are to be applied shall be free from grease, dirt, dust, paint, mill scale, curing compound, laitance, and other foreign material.

Concrete surfaces on which epoxy compounds are to be used shall be ground or sandblasted sufficiently to expose the sound concrete. Surfaces that are not to receive epoxy compounds shall be protected from sandblasting. Immediately following sandblasting, the surface shall be thoroughly cleaned.

Before epoxy compounds are applied to metal surfaces, surfaces shall be sandblasted to a bright metallic luster.

Wood surfaces shall be sanded to the texture of new wood.

2. **Mixing:** Epoxy mortar shall be made by blending sand, epoxy resin, and hardener in accordance with the manufacturer's instructions.

Batch sizes shall be limited to the maximum batch size recommended by the manufacturer. Mixed epoxy compounds shall be used within the manufacturer's specified pot life. Solvents or other materials shall not be added to the mixture.

3. **Application:** Masking shall be used to form straight edges. Epoxy resin shall not be allowed to flow into or over expansion joints. The first coat of epoxy resin shall be applied at the rate of 1 gallon per 75 square feet. Sand shall be broadcast into the wet epoxy in sufficient quantity, approximately 11 pounds per square yard, to cover the epoxy completely. Sand shall be firmly embedded so that at least 95 percent of the deck area displays a sand surface after brooming. Brooming shall not be performed until the epoxy resin has cured sufficiently to prevent tearing. After curing, unbonded sand shall be broomed from the surface and may be reused if uncontaminated. The second coat of epoxy resin shall be applied at the rate of 1 gallon of epoxy per 50 square feet. Requirements pertaining to masking, epoxy, flow, sand broadcasting, percentage of embedment, curing, and brooming shall also apply to the second coat of epoxy resin.

At edges of the waterproofing system and at any point where it is punctured by appurtenances such as drains or pipes, suitable provisions shall be made to prevent water from getting between the waterproofing and the waterproofed surface.

The waterproofing system shall be extended as follows: 1 inch up faces of curbs; continuously across abutment backwalls and at least 6 inches down the back of backwalls; at least 12 inches onto approach slabs; and continuously across joints except expansion joints.

When applied to prestressed concrete slab and box beam units for new construction, application shall be made at the prestressing plant. Joints and damaged areas shall be waterproofed after erection.

4. **Curing:** Curing time shall conform to the manufacturer's recommendations. During this time, both pedestrian and vehicular traffic shall be barred from freshly placed surfaces.

(b) **Membrane:**

1. **Waterproofing membrane sealant:** The sealant shall consist of a prefabricated membrane or liquid membrane conforming to one of the following systems:

System A: A primer and prefabricated membrane consisting of a laminate formed with suitably plasticized coal tar and reinforced with nonwoven synthetic fibers or glass fibers.

System B: A primer, mastic, and prefabricated membrane consisting of a laminate formed and rubberized asphalt and reinforced with synthetic fibers or mesh.

System C: A primer and prefabricated membrane consisting of a laminate formed with suitably plasticized asphalt, reinforced with open weave fiber glass mesh, and having a thin polyester top surface film.

System D: A hot-poured liquid elastomeric membrane with protective covering.

System E: A surface conditioner and a hot-applied rubberized asphalt membrane with protective covering.

2. **Construction:** On new decks, the waterproofing membrane system shall not be placed until at least 28 days after deck concrete placement unless otherwise directed by the Engineer.

Each phase of the bridge deck construction shall be completed, including the placing of the surface course overlay, before roadway traffic may be placed on that portion of the bridge structure. In order to minimize possible damage to the membrane, placing of the membrane sealant system will not be permitted until the adjacent roadway binder course has been completed and is ready for traffic. Only vehicles necessary for construction, including the paver, will be permitted on the structure during and after the placing of the membrane system, and such vehicles shall be rubber tired or have rubber-covered treads. The Contractor shall be responsible for maintaining the condition of the membrane system until covered with the bituminous concrete surface course overlay.

All methods employed in performing the work and equipment, tools, and machinery used for handling materials and executing any part of the work shall be subject to the approval of the Engineer before the work is started, and whenever found unsatisfactory, they shall be changed and improved as required. Equipment, tools, machinery, and containers used shall be kept clean and maintained in satisfactory working condition.

Work shall not be performed during wet weather conditions. In addition, work shall not be performed when the deck and ambient air temperatures are below 50 degrees F except for application of System E, for which the minimum temperature shall be 20 degrees F. The deck surface shall be thoroughly dry at the time of the application of the primer or liquid membrane.

Concrete parapet surfaces and railing, including armor plates for the elastomeric joint seals, shall be protected to prevent their being defaced by primer or membrane material. Should defacement occur, the Contractor shall clean surfaces on the structure to the satisfaction of the Engineer.

Between the time the bridge deck is cleaned and prepared for primer and the time the membrane system is placed, no vehicles, including mechanical spreaders, shall be operated on the area being treated. Only the necessary personnel and equipment to perform the required work will be allowed on the treated surface, and only at such time and in such manner as approved by the Engineer. Care shall be taken to prevent sudden starts, stops, or turns by equipment. All other traffic shall be maintained on portions of the structure that are not being given the membrane protection.

3. **Preparation of concrete deck:** Surfaces that are to be covered shall be thoroughly cleaned by the use of sandblasting, air jets, mechanical sweepers, hand brooms, or other approved methods, or as required by the Engineer, until the surface is free of sand, clay, dust, and loose or foreign matter. Water shall not be used to clean the deck unless authorized by the Engineer.

Any accumulations of oil or grease shall be scraped off the roadway surface and cleaned with a strong caustic solution. The resulting residue shall be thoroughly flushed

away with clean water. Cleaned areas shall be primed without delay as soon as they are dry. Dust and dirt shall be blown off with air jets immediately preceding application of primer or liquid membrane.

Any sharp concrete protrusions on the deck surface that would puncture the membrane shall be removed prior to application of the membrane.

4. Construction procedures:

- a. **Application of primer:** The primer shall be applied to the cleaned concrete surfaces at the rate and in accordance with the procedure recommended by the membrane manufacturer. Surfaces to be covered by prefabricated membrane shall be uniformly coated with primer. Drying time prior to applying the membrane shall be as recommended by the manufacturer.
- b. **Application of membrane:** Before applying the membrane, the direction of operation of the paving equipment shall be ascertained. Unless otherwise approved, each phase of preformed waterproofing membrane construction shall begin at the low point of the surface to be waterproofed and shingled so that water will run over and not against any laps. At deck joints, the membrane shall extend to the edge of the joint opening as shown on the plans.
 - (1) Prefabricated membrane shall be applied to the primed curb and bridge deck surfaces by either hand methods or mechanical applicators. Prefabricated membranes shall be placed in such a manner that a shingling effect will be achieved, and any water that accumulates will drain toward the curb and the drainpipes. Each strip shall be overlapped a minimum of 4 inches. The membrane sections shall be placed so that end laps will be in the direction of the paving operation.

An adhesive or a wide tipped torch shall be used, if necessary, to ensure a good seal of the prefabricated membrane joints. Hand rollers or other satisfactory pressure apparatus shall be used on the applied membrane to ensure firm and uniform contact with the primed concrete surfaces. Special care shall be used at the curb face to ensure that the membrane is uniformly and positively adhering to the concrete.

Prefabricated membranes shall be free of wrinkles, air bubbles, and other placement defects. Any torn or cut areas or narrow overlaps shall be patched using a satisfactory adhesive and by placing sections of the membrane over the defective area in such a manner that the patch extends at least 6 inches beyond the defect. The patch shall be rolled or firmly pressed onto the surface.

- (2) Liquid elastomeric membrane shall be heated in a manner as recommended by the membrane manufacturer to 375 degrees F. Then, it shall be applied to the cleaned concrete surface by spraying with a special type nozzle as recommended by the membrane manufacturer or poured onto the concrete surface and worked into the surface with a silicone rubber squeegee to a uniform 90-mil thickness for System D and 125-mil thickness for System E.

- c. **Application of protective covering:** For Systems A, B, and C, protective covering shall be used when or as recommended by the membrane manufacturer. For Systems D and E, the protective covering shall be applied immediately following application of the liquid elastomeric membrane and prior to cooling before loss of adhesion between materials. Protective covering shall be placed parallel to the centerline of the bridge, unless otherwise approved by the Engineer, and with the talc-coated side up.

In the event protective covering is recommended by the prefabricated membrane manufacturer, a suitable compatible mastic or adhesive cement, as recommended by the membrane manufacturer, shall be used to adhere any protective covering material securely to membrane surfaces. Protective covering strips shall be butted tightly together at both longitudinal and transverse joints. Protective covering material shall be securely bonded to the membrane material and shall be essentially free of wrinkles, bubbles, and other placement defects. Wrinkles and “fish mouths” rising more than 1/2 inch above the bridge deck shall be split and either removed or lapped and securely bonded together.

- d. **Application of surface course overlay:** Unless otherwise approved by the Engineer; an asphalt concrete surface course mixture shall be placed within 24 hours after the placement of the waterproofing membrane system in accordance with the requirements of Section 315 except as modified herein.

The asphalt concrete surface course shall be of the type and amount specified on the plans with a minimum compacted depth of 1 1/2 inches. The paving operation shall be in the same direction as the end laps of the membrane. When a protective covering is used, a tack coat shall be applied prior to the paving operation.

The mixing discharge temperature of the mixture shall not exceed 310 degrees F. The temperature of the mixture at the time of placement shall be not less than 275 degrees F. The mixture shall be dumped directly into the paver hopper. After filling the hopper, the truck shall pull forward and shall not be in contact with the paver while it is moving. Dumping the mixture onto the deck ahead of the paver will not be permitted. The mixture shall be spread and rolled in such a manner that the protective coating, when used, will not be damaged. The temperature of the mixture at the time of rolling and compacting shall be not less than 235 degrees F. When using vibratory roller equipment, the vibrator shall not be activated.

- e. **Performance:** After completion of the surface course, the waterproofing effectiveness of the membrane pavement system will be determined. The minimum electrical resistance shall be 500,000 ohms when tested in accordance with VTM-39. Areas designated by the Engineer as having a lower resistance reading than 500,000 ohms will be evaluated by the Department, and those areas determined by the Engineer to be detrimental to the effectiveness of the system shall be repaired at the Contractor’s expense by removing the pavement and then replacing or repairing the defective membrane. Asphalt pavement shall then be placed in a manner that will yield a neat-appearing, smooth-riding pavement. In the event more than 30 percent of the bridge deck area is shown defective by tests and is determined by the Engineer to be detrimental to the effectiveness of the system, the entire asphalt pavement and membrane system shall be removed and the deck cle-

aned in a satisfactory manner. The entire membrane-pavement system shall then be replaced in accordance with the requirements herein at the Contractor's expense.

416.04—Measurement and Payment

Waterproofing will be measured and paid for in square yards of completed deck surface covered between the beginning and end stations of the bridge. For applications other than bridge decks, waterproofing will be measured and paid for in square yards of completed surface as shown on the plans.

The cost of waterproofing applied to prestressed concrete members before erection and the cost of waterproofing joints and damaged areas shall be included in the price bid per member.

Payment will be made under:

Pay Item	Pay Unit
Waterproofing	Square yard

SECTION 417—DAMP-PROOFING

417.01—Description

This work shall consist of furnishing and applying damp-proofing material to concrete surfaces in accordance with the plans and these specifications.

417.02—Materials

Materials shall conform to the applicable requirements of Section 213.

417.03—Procedures

- (a) **Surface Preparation:** Surfaces shall be cleaned of loose, foreign material and shall be dry. The Engineer may require the surface to be scrubbed with water and a stiff brush, after which it shall be allowed to dry before application of primer.
- (b) **Application:** The clean surface shall be brush painted or spray painted with at least two coats of primer, using at least 1/8 gallon per square yard of surface per coat. On the primed surface, one application of an asphalt seal coat shall be applied by brush, using at least 1/10 gallon per square yard.

Asphalt shall be confined to areas to be damp-proofed and shall not be dripped or spread on any other parts of the structure.

417.04—Measurement and Payment

Damp-proofing, when a pay item, will be paid for at the contract unit price per square yard. When not a pay item, the cost thereof shall be included in the price for other appropriate pay items.

Payment will be made under:

Pay Item	Pay Unit
Damp-proofing	Square yard

SECTION 418—TIMBER STRUCTURES**418.01—Description**

This work shall consist of furnishing and erecting timber materials required to complete a structure in accordance with these specifications and in conformity with the lines and grades shown on the plans or as established by the Engineer.

418.02—Materials

- (a) **Lumber and Timber:** Lumber and timber shall conform to the requirements of Section 236.
- (b) **Structural Shapes:** Rods, plates, shapes, and eyebars shall conform to the requirements of Section 226.
- (c) **Castings:** Castings shall be cast steel or gray iron, as shown on the plans, conforming to the applicable requirements of Section 224.
- (d) **Hardware:** Machine bolts, drift bolts, and dowels shall conform to the requirements of Section 226. Washers may be ogee gray iron or malleable castings or may be cut from mild steel plate as shown on the plans.

Machine bolts shall have square heads and nuts. Nails shall be cut or round wire of standard form. Spikes shall be cut, wire, or boat spikes as shown on the plans.

Nails, spikes, bolts, dowels, washers, and lag screws shall be black or galvanized, as specified on the plans.

Other hardware, except malleable iron connectors, shall be galvanized in accordance with the requirements of Section 233 or cadmium plated in accordance with the requirements of ASTM A165, Type OS.

- (e) **Paint:** Paint shall conform to the requirements of Section 231.

418.03—Procedures

- (a) **Storing Material:** Lumber and timber on the work site shall be stored in stacks or ricks.

Material shall be stacked at least 12 inches above the ground surface and sloped. It shall be protected from weather by a suitable covering. The ground underneath and in the vicinity of material shall be cleared of weeds and rubbish.

Untreated material shall be open stacked, and treated material shall be close stacked.

- (b) **Treated Timber:** Treated timber shall be handled with rope slings without sudden dropping, breaking of outer fibers, or bruising or penetrating of the surface with tools such as cant hooks, peaveys, pikes, or hooks.

Cutting, framing, and boring of treated timbers shall be performed before treatment insofar as is practicable. When treated timbers are to be placed in water infested by marine borers, as determined by the Engineer, untreated cuts, borings, or other joint framings below the high water elevation shall be avoided.

Cuts in treated piles or timbers and abrasions, after having been carefully trimmed smooth, shall be brush coated with at least two applications of the preservative used in the treatment of the pile.

Bolt holes bored after treatment shall be treated with a preservative. After being treated, unfilled holes shall be plugged,

Whenever forms or temporary braces are attached to treated timber with nails or spikes, holes shall be filled by driving galvanized nails or spikes flush with the surface or by plugging as required for bolt holes.

- (c) **Untreated Timber:** Ends, tops, and contact surfaces of sills, caps, floor beams, stringers, and bracing and truss units shall be thoroughly coated with two coats of preservative before assembly. The back faces of bulkheads and other timber that will be in contact with earth, metal, or other timber shall be similarly treated.
- (d) **Treatment of Pile Heads:** After required cutting to receive caps and prior to placement of caps, pile heads shall be treated to prevent decay. Heads of timber piles shall be protected by one of the following methods, as indicated on the plans. If not otherwise indicated, Method A shall be used.
1. **Method A—zinc covering:** The sawed surface shall be brush coated with three applications of a preservative. Before the cap is placed, a sheet of 12 gage (0.028 inch) zinc shall be placed on each pile head. The sheet shall be of sufficient size to project at least 4 inches outside the pile and shall be bent down, neatly trimmed, and securely fastened to the face of the pile with large-headed galvanized roofing nails.
 2. **Method B—fabric covering:** Heads of piles shall be covered with alternate layers of hot pitch and cotton fabric for waterproofing, using four applications of pitch and three layers of fabric. The cover shall measure at least 6 inches more in dimension than the diameter of the pile and be neatly folded down over the pile and secured by large-headed galvanized nails or by binding with at least seven complete turns of galvanized wire

securely held in place by large-headed galvanized nails and staples. Edges of fabric projecting below the wire wrapping shall be trimmed to present a neat appearance.

- (e) **Holes for Bolts, Dowels, Rods, and Lag Screws:** Holes for round drift bolts and dowels shall be bored with a bit 1/16 inch less in diameter than the bolt or dowel to be used. The diameter of holes for square drift holes or dowels shall be equal to the least dimension of the bolt or dowel.

Holes for machine bolts shall be bored with a bit the same diameter as the bolt.

Holes for rods shall be bored with a bit 1/16 inch greater in diameter than the rod.

Holes for lag screws shall be bored with a bit not larger than the body of the screw at the base of the thread.

- (f) **Bolts and Washers:** A washer shall be used under bolt heads and nuts that would otherwise come in contact with wood. Bolts shall be checked after nuts have been finally tightened.
- (g) **Countersinking:** Countersinking shall be performed wherever smooth faces are required. Recesses in horizontal surfaces shall be painted with a preservative and filled with hot pitch after the bolt or screw is in place.
- (h) **Framing:** Lumber and timber shall be cut and framed to a close fit so that the joints will have an even bearing over the contact surfaces. Mortises shall be true to size for their full depth, and tenons shall fit snugly. Shimming will not be permitted in making joints, and open joints will not be accepted.
- (i) **Pile Bents:** Preparing and driving piles shall be in accordance with the requirements of Section 403.

Piles for any one bent shall be carefully selected as to size to avoid undue bending or distortion of the sway bracing. Care shall be taken in distributing piles of varying sizes to secure uniform strength and rigidity in bents of any given structure.

Cutoffs shall be accurately made to ensure a uniform bearing between the cap and piles of a bent.

- (j) **Framed Bents:**

1. **Mud sills:** Untreated timber used for mud sills shall be of heart cedar, heart cypress, redwood, or other durable timber. Mud sills shall be firmly and evenly bedded to solid bearing and tamped in place.
2. **Concrete pedestals:** Concrete pedestals for the support of framed bents shall be finished so that sills or posts will take an even bearing. Dowels or anchor bolts at least 3/4 inch in diameter shall be set in pedestals when they are cast for anchoring sills or posts.
3. **Sills:** Sills shall have a true and even bearing on mud sills, piles, or pedestals. They shall be drift bolted to mud sills or piles with bolts at least 3/4 inch in diameter and extending into the mud sills or piles at least 6 inches. When possible, earth shall be removed from contact with sills so that there will be free air circulation.

4. **Posts:** Posts shall be fastened to pedestals with dowels at least 3/4 inch in diameter, extending at least 6 inches into the posts.

Posts shall be fastened to sills by one of the following methods, as indicated on the plans: by dowels at least 3/4 inch in diameter extending at least 6 inches into posts and sills or by drift bolts at least 3/4 inch in diameter driven diagonally through the base of the post and extending at least 9 inches into the sill.

- (k) **Caps:** Timber caps shall be placed with ends aligned in a manner to secure an even and uniform bearing over the tops of supporting posts or piles. Caps shall be secured by drift bolts at least 3/4 inch in diameter extending at least 9 inches into the posts or piles. Drift bolts shall be in the approximate center of the post or pile.
- (l) **Bracing:** Ends of bracing shall be bolted through the pile, post, or cap with a bolt at least 5/8 inch in diameter. Intermediate intersections shall be bolted or spiked with wire or boat spikes, as indicated on the plans. In all cases, spikes shall be used in addition to bolts.
- (m) **Stringers:** Stringers shall be sized at bearings and placed in position so that knots near edges will be in the top portions of stringers.

Outside stringers may have butt joints with ends cut on a taper, but interior stringers shall be lapped to take bearing over the full width of the floor beam or cap at each end. Lapped ends of untreated stringers shall be separated at least 1/2 inch for the circulation of air and securely fastened by drift bolting where specified. Where stringers are two panels in length, joints shall be staggered.

Cross bridging between stringers shall be neatly and accurately framed and securely toenailed with at least two nails in each end. Cross-bridging units shall have full bearing at each end against the side of stringers. Cross bridging shall be placed at the center of each span.

- (n) **Plank Floors:** Planks shall be surfaced on four sides (S4S).

Single-plank floors shall consist of a single thickness of plank supported by stringers or joists. Planks shall be carefully graded as to thickness and placed so that no two adjacent planks shall vary in thickness by more than 1/8 inch. Each plank shall be placed heart side down, firmly jacked together, and securely fastened to each joist.

- (o) **Wheel Guards and Railings:** Wheel guards and railings shall be erected true to line and grade. Wheel guards, rails, and rail posts shall be surfaced on four sides (S4S). Wheel guards shall be laid in sections at least 12 feet in length.
- (p) **Painting:** Rails and rail posts, untreated timber, or timber treated with a preservative shall be painted with three coats of paint.

Metal parts, except hardware, shall be given one coat of shop paint and, after erection, three coats of field paint.

Timber shall be painted with No. 11 paint.

418.04—Measurement and Payment

Lumber and timber will be measured in units of 1,000 foot-board-measure (MFBM) for materials placed in the finished structure and will be paid for at the contract unit price per MFBM. Computations for lumber quantities will be based on nominal sizes, complete-in-place. No other allowance for waste will be made.

Structural steel will be paid for in accordance with the requirements of Section 407.

Painting timber structures, when a pay item, will be paid for at the contract lump sum price. When not a pay item, the cost thereof shall be included in the price for other appropriate pay items.

These prices shall include preparing surfaces and preservative treatment.

Payment will be made under:

Pay Item	Pay Unit
Lumber (Treated or untreated)	MFBM
Painting timber structures	Lump sum

SECTION 419—BRIDGE CONDUIT SYSTEMS AND LIGHTING SYSTEMS

419.01—Description

This work shall consist of furnishing and installing a bridge conduit system and a bridge lighting system in accordance with these specifications and in conformity with the lines and details shown on the plans or as established by the Engineer.

419.02—Materials

Conduit, boxes, and fittings shall be as specified in Section 238.

419.03—Procedures

The Contractor shall verify or locate the origin of power sources when modifying or relocating existing electrical systems and shall advise the Engineer at least 48 hours prior to the anticipated time of de-energizing the electrical system. Workmanship shall conform to the standards of NEC and the requirements of the local power company.

Conduit, fittings, and electrical items shall be installed in accordance with the requirements of Section 700.

419.04—Measurement and Payment

Bridge conduit systems, when a pay item, will be paid for at the contract lump sum price per structure. When not a pay item, the cost thereof shall be included in the price for other appropriate pay items.

Bridge lighting systems will be paid for at the contract lump sum price per structure.

Payment will be made under:

Pay Item	Pay Unit
Bridge conduit system (B or Str. No.)	Lump sum
Bridge lighting system (B or Str. No.)	Lump sum

SECTION 420—PREFORMED ELASTOMERIC JOINT SEALER

420.01—Description

This work shall consist of furnishing and installing preformed elastomeric joint sealer in accordance with these specifications and in conformity with the lines shown on the plans or as established by the Engineer.

420.02—Materials

Material for preformed elastomeric joint sealer and lubricant adhesive shall conform to the requirements of Section 212.02(i). The joint sealer shall be furnished in the form of an extruded compartmented tube.

420.03—Procedures

- (a) **Preparation of Joint:** The joint shall be formed to provide the nominal opening at the specified temperature as shown on the plans. Sides of the joint shall be parallel to each other. Edges of concrete or epoxy mortar adjacent to the joint shall be rounded to a radius of not more than 1/4 inch. A joint having an insufficient opening may be required to be sawed or ground to the proper size. If a joint opening is larger than specified, the Contractor may furnish a larger-size sealer up to 4 inches in its uncompressed width as determined by the Engineer. If the joint opening is larger than that which will accommodate the larger sealer, the end of the slab shall be cut back at least 6 inches and rebuilt with Class A4 concrete to obtain the required joint opening. The cost of such additional work or material shall be borne by the Contractor unless designated in the Contract as a pay item.

Before placement of sealer, the joint shall be thoroughly cleaned by brushing, compressed air, or other means so that it is free from dust, oil, grease, or other foreign materials.

- (b) **Installation:** Sealer shall be installed using methods and procedures recommended by the manufacturer of the sealer. A lubricant adhesive shall be used. During installation, the sealer shall not be subjected to lengthwise stretching. The length to be installed shall be measured prior to installation and cut or marked to indicate the installed length.

No splices will be permitted in joint sealers for lengths less than 50 feet. For lengths greater than 50 feet, one splice will be permitted for each additional 50 feet. Splices shall be made by the manufacturer at the manufacturing plant. Longitudinal joint sealers may be field spliced where intersected by transverse joints. Field splices shall be sealed with a sealant recommended by the manufacturer.

The top surface of the sealer after installation shall be $3/8 \pm 1/16$ inch below the surface of the adjacent roadway.

420.04—Measurement and Payment

Preformed elastomeric joint sealer, when a pay item, will be measured in linear feet along the pavement surface from out to out of the deck slab, complete-in-place, and will be paid for at the contract unit price per linear foot. When not a pay item, the cost thereof shall be included in the price for other appropriate pay items.

Payment will be made under:

Pay Item	Pay Unit
Preformed elastomeric joint sealer (Width)	Linear foot

SECTION 421—ELASTOMERIC EXPANSION DAMS

421.01—Description

This work shall consist of furnishing and installing elastomeric expansion dams in accordance with these specifications and in conformity with the lines, elevations, and locations shown on the plans or as established by the Engineer.

421.02—Materials

Materials shall conform to the requirements of Section 212.02(j).

421.03—Procedures

Working drawings showing the complete details and dimensions of the dam and other pertinent information, such as required special shop fabrication necessary for installation of practical leakproof joints, shall be submitted to the Engineer for review in accordance with the requirements of Section

105.10. The Contractor shall provide a factory-trained representative on the job site prior to and during the initial installation of the expansion dam.

Dams shall consist of elastomeric material and metal components arranged to provide for expansion and contraction movement of the bridge deck.

Expansion and contraction movements between adjacent spans of the bridge deck shall be compensated for entirely by deformation of the elastomer component, without detriment to it, and shall cause no appreciable change in the elevation of the deck surface. The opening between the rigid portions of dams at the roadway level shall be not more than 3 1/2 inches at maximum opening.

Dams shall seal the deck surface, gutters, curbs, and parapets to prevent water and other contaminants from seeping onto the substructure.

Dams shall have a continuous elastomeric membrane. Field-vulcanized joints for each dam may be permitted in accordance with plan details.

Dams shall be cast in place, with top surfaces parallel to the bridge deck. Concrete shall be placed beneath the dam in a manner to prevent the formation of air pockets in the concrete.

Final sealing of the finished dam shall be completed as soon as possible after installation. Bolt cavities shall be wire brushed and filled with sealant. Edges of the dam, exposed ends, and other areas of possible leakage shall be filled with sealant. Sealant shall be smoothed, and any excess scraped off before the initial set.

421.04—Measurement and Payment

Elastomeric expansion dams will be measured in linear feet of dam, complete-in-place, for the movement range specified and will be paid for at the contract unit price per linear foot. The movement range will be 0 to 2, 2 to 3, and 3 to 4 inches. When not a pay item, the cost thereof shall be included in the price for other appropriate pay items. This price shall include furnishing, installing, components, and anchoring devices.

Payment will be made under:

Pay Item	Pay Unit
Elastomeric expansion dam (Movement range)	Linear foot

SECTION 422—NAVIGATION LIGHTS

422.01—Description

This work shall include furnishing, installing, and wiring navigation lights complete and ready for service on structures shown on the plans or as directed by the Engineer.

422.02—Materials

- (a) **Conduit, boxes, and fittings** shall conform to the requirements of Section 238.
- (b) **Conductors and electrical components** shall conform to the requirements of Section 238. No. 8 single-conductor wire shall be used from the connection at the service pole to the first junction box on the structure, and No. 10 single-conductor wire shall be used for other wiring.

422.03—Procedures

- (a) **Electrical Service:** Power will be furnished within 100 feet of the end of the bridge by 120/240-volt single-phase, 60-hertz, three-wire service. The Contractor shall furnish and install a wood pole on which the power company will terminate its service lines. The Contractor shall install service entrance equipment on the wood pole in accordance with the requirements of Standard SE-8. The safety switch shall be rated at 30 amp, 240 volts, two pole, solid neutral 120 volt AC, and fused for 15 amps.
- (b) **Conduit, Boxes, and Fittings:** These shall be installed in accordance with the requirements of Section 700.
- (c) **Lights:** Lights shall be furnished and installed in accordance with the latest rules and regulations for lighting bridges furnished by the U.S. Coast Guard and shall be subject to their approval. Materials and workmanship shall conform to the standards of NEC and the requirements of the local power company. Lights shall be equipped with an automatic lamp changer with a capacity of four lamps and a step-down transformer to operate standard low-voltage prefocused lamps. Lights shall be arranged to be turned on and off automatically so that they will burn continuously from sunset to sunrise.

Lights shall be controlled by a photoelectric control. The control shall operate a two-pole, 30-amp, normally open, magnetic relay mounted in a NEMA 3R control center cabinet. The control for the lights shall be mounted on the service pole.

422.04—Measurement and Payment

Navigation lights will be paid for at the contract lump sum price, wherein no measurement will be made. This price shall include furnishing and installing conduit, conductor cable, service entrance equipment, junction boxes, navigation lights, lamp changer, photoelectric control and step-down transformer, control center cabinet, and safety switch.

Payment will be made under:

Pay Item	Pay Unit
Navigation lights	Lump sum

Division V
INCIDENTAL CONSTRUCTION

SECTION 501—UNDERDRAINS

501.01—Description

This work shall consist of constructing underdrains, using pipe, aggregate, and geosynthetics, in accordance with these specifications and in conformity to the lines and grades shown on the plans or as designated by the Engineer.

501.02—Materials

- (a) **Pipe** shall conform to the requirements of Section 232.
- (b) **Aggregate** shall conform to the requirements of Section 202 or 203.
- (c) **Geosynthetics, to include geotextile fabric and prefabricated geocomposite pavement edgedrains**, shall conform to the requirements of Section 245.

501.03—Procedures

- (a) **Excavation:** The trench shall be excavated so that the walls and bottom are free of loose and jagged material. Large depressions shall be filled with sandy material, and sharp contours and rises shall be leveled. Excavated material shall be handled in a way that prevents contamination with the aggregate used to backfill the trench for the underdrain.
- (b) **Placing Geosynthetics:** When geotextile fabric or prefabricated geocomposite pavement edgedrain (PGPE) is required, it shall be placed as shown on the plans. Torn or punctured fabric shall be replaced at the Contractor's expense. Splices, when required for PGPE, shall be made using splice kits furnished by the manufacturer and in accordance with the manufacturer's written instructions. Spliced joints shall not damage the panel, shall not impede the open flow area of the panel, and shall maintain the vertical and horizontal alignment of the drain within 5 percent. Splices shall be made in such a manner as to prevent infiltration of the backfill or any fine material into the water flow channel.
- (c) **Installing Pipe:** Perforated pipe shall be placed with the perforations facing downward on a bed of aggregate material. Pipe sections shall be joined with appropriate couplings. Semi-round underdrain pipe shall be placed with the rounded section down.

Wherever the depth of the trench is modified to a lesser depth than shown on the standard drawings, concrete or corrugated pipe shall be used.

Pipe shall be placed with the bell end upgrade. Open joints shall be wrapped with the same geotextile used for lining the excavation.

Upgrade ends of pipe, except for combination underdrains, shall be closed with suitable plugs. Where an underdrain connects with a manhole or catch basin, a suitable connection shall be made through the wall of the manhole or catch basin.

After the Engineer has approved the pipe installation, aggregate backfill material shall be placed and compacted. Pipe and covering at open joints shall not be displaced during subsequent operations.

Outlet pipes shall be installed at the low points of a sag.

Endwalls for outlet pipes shall be placed on a prepared surface that has been compacted to comply with the requirements of Section 303.04. If settlement of the endwall occurs, the Contractor shall make necessary repairs at his expense.

Prior to final acceptance of the underdrain system, the Contractor shall conduct a video inspection of the installed system in accordance with the requirements of VTM-108.

- (d) **Combination Underdrain Outlets:** Pipe shall be placed in the trench with sections securely joined. After the Engineer has approved pipe installation, the trench shall be backfilled with aggregate material in layers not more than 6 inches in depth and thoroughly compacted.
- (e) **Inspection Ports:** Inspection ports shall be installed on the PGPE at a rate of two per mile of installed PGPE or a minimum of four per project. Inspection ports shall meet and be installed in accordance with the manufacturer's specification. The Department will use these ports in conjunction with a borscope camera as part of the basis for acceptance of the PGPE. The Department will perform inspection after PGPE installation but prior to paving of the shoulder. Bends, water flow restrictions, J-shaped panels, tears in the geotextile, debris in pipes, and sags are unacceptable and shall be removed and replaced at no cost to the Department.

501.04—Measurement and Payment

Underdrains and combination underdrains will be measured in linear feet, complete-in-place, and will be paid for at the contract unit price per linear foot. The contract unit price for underdrains installed at depths greater than those shown in the standard drawings will be increased 20 percent for each 1-foot increment of increased depth. No adjustment in the contract unit price will be made for an increment of depth of less than 6 inches. When drains are to be placed under pavement that is not constructed under the Contract, the contract unit price shall include removing and replacing pavement.

Geotextile drainage fabric, when a pay item, will be measured and paid for in accordance with the requirements of Section 504.04.

Outlet pipe for underdrains will be measured in linear feet, complete-in-place, and will be paid for at the contract unit price per linear foot.

These prices shall include geotextile drainage fabric when not a pay item, excavating, aggregate, backfilling, compaction, splicing, inspection ports, if any, disposing of surplus and unsuitable materials, and installing outlet markers.

Payment will be made under:

Pay Item	Pay Unit
Underdrain (Standard)	Linear foot
Combination underdrain (Standard)	Linear foot
Outlet pipe	Linear foot

SECTION 502—INCIDENTAL CONCRETE ITEMS

502.01—Description

This work shall consist of constructing curbs, gutters, combination curbs and gutters, paved ditches, paved flumes, bridge drainage aprons and chutes, concrete median barriers, median strips, sign islands, and directional island curbs in accordance with these specifications and in conformity to the lines and grades shown on the plans or as established by the Engineer.

502.02—Materials

- (a) **Hydraulic cement concrete** shall conform to the requirements of Section 217. With the approval of the Engineer, the design of the mixture may be modified to accommodate the placement equipment to be used.
- (b) **Asphalt concrete** shall conform to the requirements of Section 211.
- (c) **Preformed joint filler** shall conform to the requirements of Section 212. Material shall be approximately 1/2 inch in thickness and shall have a width and depth equal to those of the incidental structure.
- (d) **Curing materials** shall conform to the requirements of Section 220.
- (e) **Reinforcing steel** shall conform to the requirements of Section 223, Grade 40 or 60.
- (f) **Rubble stone** shall conform to the requirements of Section 205.
- (g) **Grout** shall conform to the requirements of Section 218.
- (h) **Foundation course** shall be aggregate No. 68 conforming to the requirements of Section 203.
- (i) **Dry filler** shall consist of aggregate conforming to the requirements of Section 202 or 203, as applicable.
- (j) **Seed** shall conform to the requirements of Section 244.
- (k) **Topsoil** shall conform to the requirements of Section 244.

502.03—Procedures

The foundation shall be constructed to the required elevation. Unsuitable material shall be removed and replaced as directed by the Engineer. The subgrade shall be thoroughly compacted and shaped to provide a uniform, smooth surface. The foundation for hydraulic cement concrete items shall conform to the specified density of the course and shall be moist when concrete is placed.

Immediately following finishing operations, hydraulic cement concrete shall be cured and protected in accordance with the requirements of Section 316.04.

- (a) **Fixed Forms Requirements:** Fixed forms shall be straight, free from warp, and of such construction that there will be no interference with the inspection of grade and alignment. Forms shall extend the entire depth of the item and shall be braced and secured so that no deflection from alignment or grade will occur during concrete placement. Radial forms shall be sufficiently flexible or otherwise designed to provide a smooth, uniform, curved surface of the required radius. Face forms shall be removed as soon as concrete has attained sufficient set for the curb to stand without slumping. The exposed surface shall then be smoothed by the use of a suitable finishing tool.

Transverse joints for crack control for fixed forms shall be provided at the following locations:

1. at approximately 20-foot intervals
2. at the gutter where the curb and gutter tie to the gutter apron of drop inlets
3. when the time elapsing between consecutive concrete placements exceeds 45 minutes
4. where no section shall be less than 6 feet in length.

Crack control joints may be formed by using one of the following methods:

- a. removable 1/8-inch-thick templates
- b. scoring or sawing for a depth of not less than 3/4 inch when using curb machine
- c. approved "leave-in" type insert or may be formed or created using other approved methods which will successfully induce and control the location and shape of the transverse cracks.

The joint at the gutter where the curb and gutter ties to the apron gutter of the drop inlet shall be formed by scoring or sawing.

Expansion joints shall be formed at intervals of approximately 100 feet, at all radii points at concrete entrances and curb returns, and at locations no less than 6 feet and no more than 10 feet from drop inlets.

Hydraulic cement concrete shall be sufficiently consolidated to produce a uniform, closed surface. Edges shall be rounded to a 1/4-inch radius.

Exposed surfaces except concrete median barrier immediately adjacent to the roadway shall be given a light broom finish. Concrete median barrier shall be given a Class 1 finish in accordance with the requirements of Section 404.07(a). Paved ditches and paved flumes shall be given a coarse or roughened texture. Other exposed surfaces shall be given a rough wood float finish. Mortar used in the removal of surface irregularities shall conform to the requirements of Section 218.

- (b) **Slipform Requirements:** The Contractor will be permitted to slipform incidental concrete items provided the following conditions contained herein are met. Approval by the Engineer to allow the Contractor the option of slipforming concrete items is permissive only and in no way relieves the Contractor from his responsibility to comply with the contract requirements and conditions.

Slipform equipment shall produce a product equal to or better than that produced by fixed form construction. Equipment for slipforming operations shall be designed or engineered to form the type of construction design for which its use is intended. Where equipment has been modified to such an extent that its use is questionable, the Contractor may be required at his expense to demonstrate to the Engineer's satisfaction that the equipment can consistently produce the desired type of construction. The slipform equipment shall be self-propelled and shall be equipped to consolidate, form, extrude, and finish the freshly placed concrete in such a manner that a minimum of hand finishing is required to produce a dense, consolidated, homogenous product. Slipform equipment shall be controlled to line and grade by automatic sensing, guidance, and control devices such that the machine automatically senses and follows taut guidelines or other stable reference, performing any necessary corrective action to ensure the correct grade and alignment are achieved. The Contractor shall ensure the slipform operation is planned to result in the full cross section and grade of the desired design at the beginning and end of the placement. Slipform equipment shall operate with a continuous forward movement. The Contractor shall plan and stage the work to eliminate the need for the slipform machine to be stopped during placement operations. If for any reason it is absolutely necessary to stop the forward progress of the machine, operation of the vibrating and tamping elements shall be stopped immediately. Equipment used for slipforming shall conform to the general requirements of Section 108.07. If the results of the slipform operation are not satisfactory to the Engineer in accordance with the requirements stated herein, the continued use of the equipment will not be permitted.

Concrete for use in slipform operations may be manufactured with a slump as low as zero. The top of the slump range shall conform to the requirements for the class of concrete specified on the plans or special provisions in accordance with Section 217. The concrete shall have properties that consistently maintain workability and the cross section, line, and grade of the proposed product. Concrete shall be finished to a light broom finish. If water is held back to maintain the desired slump, it may be added in increments provided the maximum water per cubic yard has not been exceeded and a minimum of 30 revolutions at mixing speed is used for complete mixing.

Where reinforcing steel is incorporated into the proposed design, it shall be uncoated steel conforming to the requirements of Section 223. Reinforcing steel shall be tied at 100 percent of the bar intersections and shall be sufficiently strengthened with braces, additional reinforcement, or chairs to make the reinforcement cage rigid so as to prevent any movement during concrete placement. If the reinforcing steel exhibits any movement during concrete placement using slipforming methods, the work shall be suspended until the reinforcing steel has been sufficiently tied and stabilized to the satisfaction of the Engineer. The rein-

forcing steel shall be continuous from fixed object to fixed object. All reinforcing steel shall have the appropriate amount of concrete cover for the particular design with a tolerance of -0 or $+1/2$ inch. In no case shall the amount of cover be less than $1\ 1/2$ inches. Reinforcing steel inserted in the freshly placed concrete shall be inserted with the use of vibration to achieve adequate bond of the reinforcing steel. Where bonding is suspect, the Engineer may require pull out tests be performed by the Contractor at his expense. If such tests confirm the presence of adequate bond, the Department will reimburse the Contractor the cost of such testing.

The maximum height of any extrusion shall be limited such that the alignment and cross-sectional shape of the design is maintained within the construction tolerances. If the Contractor elects to use or is required to use multiple placements to achieve a particular design, the Contractor shall submit a plan outlining the details of each placement for approval by the Engineer prior to beginning placement operations. Where multiple placements are permitted for installation of a particular design, the separate placements shall be staged so that any horizontal joints incorporated in the phased construction shall be arranged in such a manner as to prevent water infiltration in the final design and water flowing through any longitudinal joint.

Where weep holes are part of the proposed median barrier design, the Contractor shall use 6-inch-diameter underdrain pipe in lieu of weep holes. Underdrain pipe conforming to the requirements of Section 232 shall be installed at the grade at the bottom of the footing and shall terminate in catch basins or drop inlets.

Where naturally occurring vertical contraction cracking occurs and where there exists a grade separation on each side of the barrier, the Contractor shall install a waterproofing membrane conforming to the requirements of Section 213, spanning $1\ 1/2$ feet on each side of the contraction crack at the back surface of the higher grade side of the barrier to prevent water from passing through the barrier.

Expansion joint material $1\ 1/2$ -inch thick shall be installed adjacent to each fixed object. Expansion material shall be placed against each fixed object prior to placement of the slip-formed concrete. Contraction joints will not be required with slipformed operations provided the reinforcing steel is continuous from fixed object to fixed object.

(c) **Individual Item Requirements:**

1. **Hydraulic Cement Concrete Curbs, Gutters, Combination Curbs and Gutters, Paved Ditches, and Paved Flumes:** Where standard mountable curb or combination curb and gutter with mountable curb is specified, adjacent curbs of standard entrance gutter and standard connection for streets shall be modified to provide a mountable shape corresponding to the standard mountable shape.

Where integral curb is specified, the curb shall be placed simultaneously with or immediately after placement of the slab. The time period between slab and curb placement shall be not more than 45 minutes except as hereinafter specified. The surface of the slab on which the curb is to be placed shall be roughened, and the concrete shall be placed so as to secure a bond between the slab and curb.

When authorized by the Engineer, the Contractor may construct the integral curb by providing steel dowels $5/8$ inch in diameter, 7 inches in length, to be embedded in the

slab at 1-foot intervals. Dowels shall be placed so as to extend at least 2 inches into the curb. While the slab is still plastic, it shall be roughened to a depth of approximately 1/2 inch below the screeded surface for the full width of the curb.

Local irregularities in the face and top of curbs shall be not more than 3/8 inch in 10 feet. Vertical alignment shall be sufficiently uniform and regular to ensure complete drainage.

Any curb, gutter, or combination curb and gutter, except those on structures, may be placed by the slipform method provided the finished product is true to line, cross section, and grade and the concrete is dense and has the required surface texture. The concrete shall be of such consistency that it will maintain the desired shape or cross section of the design without support.

Where concrete curb or curb and gutter is placed over existing pavement, it shall be anchored to the existing pavement either by placing steel dowels and reinforcing steel or by using an approved adhesive. Steel dowels shall be firmly mortared with 1:1 portland cement and sand mortar in holes drilled in the pavement. If an adhesive is used, the surface of the pavement shall be thoroughly cleaned before the adhesive is applied. Adhesive shall be EP-4 epoxy resin, a two-component system conforming to the requirements of Section 243. The pavement shall be cleaned by either blast cleaning or wire brushing so that the prepared surface is free of dust, loose material, oil, or any other material that may prove deleterious to bonding.

The grade for the top of the extruded curb shall be indicated by an offset guideline set by the Contractor from survey information supplied by the Department. The forming tube portion of the extrusion machine shall be readily adjustable vertically to accommodate, when necessary, a variable height of curb conforming to the predetermined curb grade line. A grade line gage or pointer shall be attached to the machine to monitor the elevation of the curb being placed against the established grade line so as to make corrective adjustments as necessary. In lieu of a grade line gage or pointer, the extrusion machine may be operated on rails or forms set to produce the predetermined finished grade line for the curbing.

Concrete shall be continuously fed to the slipforming machine at a uniform rate. The machine shall be operated under sufficient uniform restraint of forward motion so as to produce a well-compacted homogenous mass of concrete free from surface pits larger than 1/4 inch in diameter and requiring no further finishing other than light brushing with a broom. Finishing with a brush application of grout will not be permitted.

Expansion joints shall be constructed as specified for fixed formed curbing or shall be constructed by sawing through the curb section to its full depth. The width of the cut shall be such to allow the insertion of the joint filler with a snug fit. If sawing is performed before the concrete has hardened, the adjacent portions of the curb shall be supported firmly with close fitting shields. The operations of sawing and inserting the joint filler shall be completed before curing the concrete.

If sawing is performed after the concrete has hardened, the joint filler shall be mortared in place with heavy trowel pressure. After sawing is performed, all exposed portions of the curb in the vicinity of the joint shall be covered with another application of curing

compound. At the conclusion of the curing period, the filler in each sawn joint shall be checked for tightness of fit. Any loose filler shall be mortared in place again and cured.

Within 3 to 7 days, the Contractor shall backfill curb, gutter, and combination curb and gutter to the required elevation with approved material. Backfill material shall be compacted with curbs and gutters remaining plumb.

2. **Asphalt Concrete Curbs and Paved Ditches:** The curb shall be placed on a clean dry surface. Immediately prior to placement of the asphalt mixture, a tack coat of asphalt shall be applied to the surface at a rate between 0.05 and 0.15 gallon per square yard of surface. Asphalt shall be prevented from spreading outside the area to be occupied by the curb.

Asphalt concrete curb shall be placed by a self-propelled automatic curb machine or a paver having curbing attachments to form a satisfactorily compacted curb of a uniform texture, shape, and density. The Engineer may permit construction of curbs by other means when short sections or sections with short radii are required. The resulting curbs shall conform in all respects to curbs produced by a curb machine.

Sealing or painting shall be performed only on curbs that are clean, dry, and cooled to ambient temperature.

Asphalt concrete paved ditches shall be placed and compacted so as to provide a smooth, uniform, and dense texture.

3. **Grouted Rubble Gutter:** Aggregate for the foundation course shall be spread on the subgrade to a depth of at least 4 inches.

Gutter stones shall be bedded in the foundation course perpendicular to the finished surface, flat side up, in straight rows, with the longest dimension perpendicular to the centerline of the gutter. Joints shall be broken in a satisfactory manner, and the width of interstices in the dry gutter shall be not more than 1 inch.

Stones shall be rammed until the surface is firm and conforms to the finished grade and cross section. Joints shall then be filled with dry filler to within 4 inches of the top of stones, and the surface shall be rammed to ensure proper compaction of filler. After irregularities have been corrected, cement grout shall be poured and broomed into joints and over stones. Additional grout shall be applied and brooming shall be continued until grout remains flush with the top of stones.

4. **Concrete Median Barriers:** Concrete median barriers shall be constructed in accordance with the requirements specified herein and in Sections 512, 404, and 410.

Concrete median barriers shall be constructed within an allowable tolerance of 1/2 inch for overall depth and overall width, 1/4 inch for the width of the upper portion of the barrier, and 1/4 inch per 10 feet for horizontal alignment.

After the specified curing time has elapsed, concrete median barriers for roadways shall be backfilled to the required elevation with approved material. Where crushed glass is used as porous backfill an 18-inch by 18-inch swatch of drainage fabric meeting the requirements of Section 245.03(c) of the Specifications shall be used to cover

the #4 mesh at each weep hole opening exposed directly to crushed glass, or as approved by the Engineer. Crushed glass shall be capped with concrete in accordance with the details shown on the standard drawing, or a minimum of 6 inches of other approved soil or aggregate material. Crushed glass shall not be used as porous backfill directly beneath paved surfaces for barrier applications. Material shall be thoroughly tamped in layers not more than 6 inches in depth before compaction. Delineators shall be installed on median barriers in accordance with the requirements of Section 702.03.

- (d) **Saw Cut Hydraulic Cement Concrete Items:** This work shall consist of the Contractor saw cutting to the full depth hydraulic cement concrete curb, sidewalk, and entrances as shown on the plans and as directed by the Engineer.

502.04—Measurement and Payment

Standard concrete curbs, radial curbs, standard combination curb and gutter, radial combination curb and gutter, and asphalt concrete curbs will be measured in linear feet along the face of the curb, complete-in-place, and will be paid for at the contract unit price per linear foot. The price shall include modifying curbs for standard entrance gutters, standard street connection pavement, and standard median strips. Where the curb or curb and gutter is adjacent to drop inlets, the contract unit price for the drop inlets shall include that part of the curb or curb and gutter within the limits of the structure.

Where there is no excavation within the limits of the curb, gutter, combination curb and gutter, or median barrier other than that necessary for its construction, the contract unit price shall include excavating, backfilling, compacting, and disposing of surplus and unsuitable material. Where excavation is necessary for the roadway, the part within the limits of the curb, gutter, combination curb and gutter, or median barrier section will be paid for as regular excavation in accordance with the requirements of Section 303.06.

Standard, radial, entrance, and grouted rubble gutters; paved ditches; paved flumes; street connection pavement; and bridge drainage aprons and chutes will be measured in square yards of surface area, complete-in-place, and will be paid for at the contract unit price per square yard. The price for grouted rubble gutter shall include rubble stone, grout, foundation course, and filler. When pipe drain ditch liner is substituted for standard paved ditch at the Contractor's option, payment will be made at the contract unit price for the standard paved ditch specified. When pipe drain ditch liner is specified on the plans, payment will be made at the contract unit price per linear foot, complete-in-place.

The cost of excavation below the finished grade or below the slope surface of cut or fill sections that is necessary for installing and backfilling paved ditches and flumes shall be included in the contract unit price for the paved ditch or flume. Undercut excavation below the neat lines of paved ditches in cut sections, including replacement backfill for undercut excavation and excavation above the upper lateral limits of paved ditches and paved flumes that are outside the normal plan earthwork limits, will be measured and paid for in accordance with the requirements of Section 303.06.

Cattle guards will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each.

Energy dissipators will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each.

Median barriers will be measured in linear feet along the centerline of barriers complete in place and will be paid for at the contract unit price per linear foot. Unless otherwise specified, this price shall include furnishing and placing delineators, aggregate, excavation, backfill, weep hole covering, concrete cap, dowels, and joint sealer.

Curb-cut ramps will not be measured for separate payment but will be measured in the units specified for their components.

Median strips will be measured in square yards or linear feet as specified and will be paid for at the contract unit price per square yard or linear foot.

Sign islands will be measured in units of each or square yards, complete-in-place, exclusive of posts and signs and will be paid for at the contract unit price per each or per square yard.

Directional island curbs will be measured in linear feet along the face of the curb and will be paid for at the contract unit price per linear foot.

Embankment material between curb lines will be measured and paid for in accordance with the requirements of Section 303.06 except as follows.

When there is no excavation or construction other than that necessary for constructing median strips, sign islands, or directional island curbs, the contract unit price shall include excavating, removing existing pavement, disposing of surplus and unsuitable material, backfilling, and compacting. When excavation or demolition of pavement is necessary for the adjoining roadway, that portion within the limits of the median strip, sign island, or directional island curb will be paid for as regular excavation or demolition of pavement in accordance with the requirements of Sections 303.06 and 508.03, respectively.

These prices shall include applying topsoil and seed.

Ditch flume connector will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each. This price shall include excavation when required, dowels, welded wire fabric, reinforcing steel, anchor lugs, curtain walls, and concrete.

Saw cut hydraulic cement concrete items will be measured in linear feet and paid for at the contract unit price per linear foot. This price will be considered full compensation for saw cutting the hydraulic cement concrete items to the depth specified.

Payment will be made under:

Pay Item	Pay Unit
Curb (Type and standard)	Linear foot
Combination curb and gutter (Type and standard)	Linear foot
Gutter (Type and standard)	Square yard
Paved ditch (Standard)	Square yard
Pipe drain ditch liner (Standard)	Linear foot
Paved flume (Standard)	Square yard
Energy dissipator (Standard)	Each
Entrance gutter (Standard)	Square yard
Street connection pavement (Standard)	Square yard

Pay Item	Pay Unit
Median barrier (Standard)	Linear foot
Bridge drainage apron and chute (Standard)	Square yard
Median strip (Standard width)	Square yard or Linear foot
Sign island (Standard)	Each or Square yard
Directional island curb (Standard)	Linear foot
Cattle guard (Standard)	Each
Ditch flume connector (Standard)	Each
Saw cut hydraulic cement concrete items (Depth)	Linear foot

SECTION 504—SIDEWALKS, STEPS, AND HANDRAILS

504.01—Description

This work shall consist of constructing sidewalks, steps, and handrails on steps or walls in accordance with these specifications and in conformity to the lines and grades shown on the plans or as established by the Engineer.

504.02—Materials

- (a) **Concrete** shall be Class A3 conforming to the requirements of Section 217.
- (b) **Reinforcing steel** shall conform to the requirements of Section 223.
- (c) **Curing materials** shall conform to the requirements of Section 220.
- (d) **Preformed joint filler** shall conform to the applicable requirements of Section 212. Material shall be approximately 1/2 inch in thickness and shall have a width and depth equal to those of the structure.
- (e) **Asphalt concrete** shall conform to the requirements of Section 211.
- (f) **Rails and posts** shall conform to the requirements of Section 232.02(c)4.b. Rails shall be of standard weight, and posts shall be extra strong pipe.
- (g) **Geotextile drainage fabric** shall conform to the requirements of Section 245.
- (h) **Grounding materials** shall conform to the requirements of Section 238.

504.03—Procedures

- (a) **Sidewalks:** The foundation shall be shaped and compacted to a firm, even surface.

Unsuitable material shall be removed and replaced with approved material as directed by the Engineer.

When geotextile drainage fabric is required, the designated area shall be cleared of debris prior to fabric installation. Large holes shall be filled with sandy, coarse material, and sharp contours and rises shall be leveled. Adjacent strips of geotextile drainage fabric shall be overlapped at least 12 inches. If fabric is torn or punctured, it shall be repaired with the same type of fabric. A patch shall be placed over the damaged area with an overlap of at least 12 inches in all dimensions at the Contractor's expense.

Forms shall be straight, free from warp, and of sufficient strength to resist the pressure of concrete without springing and shall extend for the full depth of concrete. Forms shall be braced and stacked so that they will remain in horizontal and vertical alignment until their removal. Where practicable, forms shall be placed at least 100 feet in advance of concrete placement. Forms shall be cleaned of foreign matter and oiled before concrete is placed.

1. **Hydraulic cement concrete sidewalk:** The foundation shall be thoroughly moistened immediately prior to concrete placement. Concrete shall be placed in forms by methods that will prevent segregation. Concrete shall be spread to the full depth and brought to grade by screeding and straightedging. Concrete shall be spaded adjacent to forms to prevent a honeycomb appearance, and the surface shall be floated with a wooden float to produce a surface free from irregularities. The final finish shall be obtained with an approved hand float that will produce a uniform surface texture. Light metal marking rollers or light brooming may be used to hide trowel marks. Outside edges of the sidewalk slab and joints shall be edged with an edging tool having a radius of 1/4 inch.

Transverse expansion joints shall be constructed at intervals of approximately 100 feet, except for closures. Slabs shall be at least 3 feet in length. Slabs shall be separated by transverse preformed joint filler, 1/2 inch in thickness, that extends from the bottom of the slab to approximately 1/4 inch below the top surface.

The slab between expansion joints shall be divided into sections approximately 5 feet in length by transverse control joints formed by a jointing tool, trowel, or another approved means. Transverse control joints shall also be provided when the time period between consecutive concrete placements is more than 45 minutes. Control joints shall extend into concrete for at least 1/4 of the depth and shall be approximately 1/8 inch in width. Where slabs are more than 7 feet in width, control joints shall be formed longitudinally to obtain secure uniform blocks that are approximately square. Transverse control joints shall also be installed where the corners of the drop inlets project into the sidewalk.

Construction joints shall be formed around appurtenances extending into and through the sidewalk. Preformed joint filler 1/4 inch thick shall be installed in these joints except that joint filler shall not be used adjacent to drop inlets. An expansion joint shall be formed and filled with 1/4-inch preformed joint filler no less than 6 feet and no more than 10 feet from drop inlets. Preformed joint filler shall also be installed between concrete sidewalk and any adjacent fixed structure that is not tied to the sidewalk with steel dowels.

Where the sidewalk is constructed in conjunction with adjacent curb, expansion joints in the curb and sidewalk shall coincide. Where such construction is adjacent to existing curb, the expansion joint shall coincide, where practicable.

Where existing or proposed structures are within the limits of the sidewalk area, concrete around them shall be scored in a block approximately 8 inches wider than the maximum dimension of the structure at the sidewalk elevation.

Preformed joint filler shall be securely fastened.

The Engineer may drill cores from the completed slab to make depth measurements. Sections showing a deficiency of more than 3/8 inch shall be removed and replaced to the specified depth at the Contractor's expense.

Immediately following finishing operations, concrete shall be cured and protected in accordance with the requirements of Section 316.04. Sidewalks shall not be opened to pedestrian traffic for the first 5 days. Vehicular traffic shall be excluded for the first 14 days or until the minimum design compressive strength is attained, whichever is the lesser time.

When liquid membrane-forming compound is used, heavy concentrations of compound that will not properly set and that may be tracked into homes or businesses shall not be used.

2. **Asphalt concrete sidewalk:** When specified on the plans, a layer of bedding material consisting of approved aggregate conforming to the grading requirements of No. 8 aggregate shall be placed in layers not more than 4 inches in depth, loose measurement, and thoroughly compacted.

Asphalt concrete shall be placed in forms in one or more courses to provide the specified depth when compacted. Compaction shall be accomplished by means of a hand-operated or power roller of a type and weight acceptable to the Engineer. Tamping by hand will be permitted in areas inaccessible to a roller. The method of compaction shall produce a smooth, dense, uniformly compacted sidewalk.

- (b) **Hydraulic Cement Concrete Steps:** Hydraulic cement concrete steps shall be constructed in accordance with the requirements of Sections 404 and 406. The tread portion of steps shall be given a light broom texture. Finished concrete shall be cured and protected in accordance with the requirements of Section 316.04.
- (c) **Handrails:** Standard or special fittings shall be used, or joints may be welded. If joints are welded, exposed joints shall be finished by grinding or filing to give a neat appearance. Handrails shall be bonded internally to maintain continuity. Electrical grounding shall conform to the requirements of Section 410.03(b).

Metal items, including rails, posts, and fittings, shall be galvanized in accordance with the requirements of Section 233 except for metal posts and rails fabricated from pregalvanized material whose ends and other exposed areas are satisfactorily repaired with a material conforming to the requirements of Section 233.

When rails are placed on a mortar rubble wall, the wall shall be capped with 14 inches of Class A3 concrete.

504.04—Measurement and Payment

Hydraulic cement concrete sidewalks will be measured in square yards of finished surface, complete-in-place, and will be paid for at the contract unit price per square yard. Each structure located within the limits of the sidewalk having an area greater than 1 square yard will be excluded in computing the square yards of sidewalk.

Asphalt concrete sidewalks will be measured in tons of asphalt mixture placed and will be paid for at the contract unit price per ton.

If regular excavation is not shown in the sidewalk area, the contract unit price for sidewalks shall include excavating, removing existing sidewalk, and disposing of surplus and unsuitable material. When the sidewalk area is located in the cross-sectional area for roadway excavation, excavation within the sidewalk area will be paid for at the contract unit price for regular excavation.

Bedding material will be measured in tons or cubic yards in accordance with the requirements of Section 109 and will be paid for at the contract unit price per ton or cubic yard.

Concrete steps will be measured in cubic yards of concrete and pounds of reinforcing steel, complete-in-place, and will be paid for at the contract unit price per cubic yard of concrete and per pound of reinforcing steel.

Handrails will be measured in linear feet along the top rail, complete-in-place, and will be paid for at the contract unit price per linear foot. This price shall include concrete placed on mortar rubble walls when the wall is not included in the Contract. This price shall include grounding.

Geotextile drainage fabric will be measured in square yards to the limits shown on the plans or as directed by the Engineer, complete-in-place, and will be paid for at the contract unit price per square yard. Overlaps, overwidths, and waste fabric will not be measured. This price shall include preparing the surface; furnishing and installing fabric, overlaps, and repair work; and excavating and backfilling toe-ins.

Payment will be made under:

Pay Item	Pay Unit
Hydraulic cement concrete sidewalk (Depth)	Square yard
Asphalt concrete sidewalk	Ton
Bedding material	Ton or Cubic yard
Concrete, Class A3, Miscellaneous	Cubic yard
Reinforcing steel	Pound
Handrail (Standard)	Linear foot
Geotextile drainage fabric (Type)	Square yard

SECTION 505—GUARDRAIL AND STEEL MEDIAN BARRIERS

505.01—Description

This work shall consist of furnishing and constructing guardrail and steel median barriers and installing reuse galvanized guardrail in accordance with the plans and these specifications and with the lines, grades, and tolerances shown on the plans or as designated by the Engineer.

505.02—Materials

- (a) **Guardrail components** shall conform to the requirements of Section 221.
- (b) **Median barriers and posts** shall conform to the contract requirements for the materials specified on the plans. Posts may be furnished with as many as six holes so that posts for installation of standard guardrail and steel median barrier may be used interchangeably.
- (c) **Concrete** shall be Class A3 conforming to the requirements of Section 217 except that mixing by hand for guardrail terminal posts will be permitted.
- (d) **Reinforcing steel** shall conform to the requirements of Section 223.
- (e) **Delineators** shall conform to the requirements of Section 235.02(d).

505.03—Procedures

The use of more than one type of post on a continuous line of guardrail will not be permitted.

Rail and elements shall be erected and aligned in a manner that will result in a smooth, continuous, taut installation. Installation shall not result in the cross section of the rail or other elements being kinked or crimped. Damaged rail or other elements will be rejected and replaced by the Contractor at no additional cost to the Department.

Guardrail delineators shall be installed in accordance with the requirements of Section 702.03. Spring cable end assemblies (compensating device) shall be provided with a permanent match mark (hack-saw cut or file mark) on the bolt shaft or spring stop and shall be referenced to the outer assembly to denote the neutral position. Cable slack shall be eliminated by tightening the steel turnbuckle cable assembly at the end opposite the compensating device until the device is compressed 3 1/2 inches. Cables with a compensating device at each end shall be tightened such that neither end indicates less than the required tension. The assembly shall remain compressed for at least 2 weeks and then loosened, and each cable shall be readjusted to the same required tension. The required tension shall be determined by tightening the turnbuckle at the end opposite the compensating device and displacing the match mark in accordance with the following:

Ambient Air Temperature (degrees F)	Match Mark Displacement (in)	Required Tension (lb)
0–19	3 1/2	1,575
20–39	3	1,350
40–59	2 1/2	1,125
60–79	2	900
80–99	1	675
100–120	1	450

Anchor assemblies shall be installed on firm earthen foundations, backfilled with suitable material in 4- to 6-inch layers, and thoroughly compacted by tamping or rodding. Stress loads shall not be placed on anchor assemblies until concrete has cured at least 28 days or has attained a compressive strength of at least 3,000 pounds per square inch as determined by field control cylinders in accordance with the requirements of Section 404.03.

On beam guardrail anchors, nuts on anchor bolts shall be tightened to a snug tight fit as defined in Section 407.06 to ensure flush contact between the beam and concrete base throughout the length of the anchor assembly.

Postholes shall be backfilled to the ground line with approved material placed in layers not more than 4 inches in height. Each layer shall be compacted by tamping.

Steel posts may be driven provided the method used will not damage the posts.

Concrete posts that are chipped or cracked will be rejected.

Wood posts shall be sawed to the dimensions shown on the plans within a tolerance of 2 percent for length and 1/4 inch scant. Wood posts may be driven, but posts that are damaged during installation shall be replaced at the Contractor's expense. If it is necessary to saw off the tops of wood posts to achieve a uniform and neat appearance, the amount sawed off shall be not more than 3 inches. Tops of sawed posts shall be brush coated with three heavy applications of the preservative used in treating the posts. Each application shall be given sufficient time to penetrate the wood. Painting wood posts will not be required. Dirt and other foreign matter shall be removed after installation.

Galvanized items shall be handled and stored in accordance with the requirements of Section 233. After erection, the threaded portion of fittings with fasteners and cut ends of bolts and galvanized surfaces that have been abraded or damaged shall be repaired in accordance with the requirements of Section 233.03.

Reuse guardrail that has maintained its original shape and is suitable for reuse may be used. When necessary, reuse guardrail shall be rebored to the dimensions shown on the standard drawings. Reuse guardrail that is damaged or lost because of the Contractor's negligence shall be replaced at the Contractor's expense.

Reuse guardrail posts and blockouts may be used provided they conform to the requirements of the standard drawings and these specifications.

The Contractor shall ensure that guardrail and barriers are kept clean during application of fertilizer, lime, tack coats, primer, or other material that cannot be readily cleaned from the guardrail or barrier.

The Contractor shall have a trained guardrail installer on the project during guardrail installation. For the purpose of this specification, a trained guardrail installer is a person who has a current certificate of training from a Department-approved guardrail installing training course.

Posts may be driven provided the equipment used is capable of installing the post without damaging it. Damaged posts will be rejected and shall be replaced by the Contractor at no additional cost to the Department. Posts shall be set plumb. Posts shall not be set with a variation of more than 1/8 inch per foot from vertical.

Posts shall be spaced in accordance with the standard drawings. A longitudinal deviation of 3/4 inch will be allowed providing the bolt holes in the guardrail, blockouts, and posts can be properly aligned without alteration or force. The height of the guardrail shall be as shown in the standard drawings.

On guardrail, nuts on bolts shall be tightened to a snug tight fit as defined in Section 407.06 to ensure full contact between the beam, blackout, and post.

The Contractor shall submit two copies of the manufacturers' recommended installation instructions for guardrail end treatments to the Engineer on the project site 2 weeks prior to the start of work.

505.04—Measurement and Payment

Guardrail will be measured in linear feet and will be paid for at the contract unit price per linear foot including hardware. Cable guardrail will be measured in linear feet from the point where cable guardrail attaches to the run-on terminal treatment to the point where cable guardrail attaches to the run-off terminal treatment, complete-in-place. Shop-curved or field-curved guardrail installed on a radius of 150 feet or less will be measured in linear feet of radial steel beam guardrail or radial steel median barrier.

The price for reuse guardrail shall include transporting and storing; repairing and installing salvaged guardrail beam; and furnishing and placing guardrail posts, blockouts, and hardware.

Steel median barriers will be measured in linear feet from center to center of end posts and will be paid for at the contract unit price per linear foot.

Intermediate anchorage assemblies will be measured in units of each and will be paid for at the contract unit price per each.

Terminal treatment for beam guardrail that terminates in back of the ditch line will be measured in linear feet along the regular guardrail section from center of end post (center of bolt group when guardrail is mounted flush to a structure) to the ditch line. The terminal section in back of the ditch line will be measured from the ditch line to center of end post.

Terminal treatment for beam guardrail, cable guardrail, and steel median barriers terminating on the roadway side of the ditch line will be measured in units of each and will be paid for at the contract unit price per each.

Reuse guardrail terminal will be measured in units of each or linear foot for the standard and type specified and will be paid for at the contract unit price per each or linear foot for the standard and type specified. This price shall include transporting and storing; repairing and installing salvaged beam; and furnishing and placing guardrail post, blockouts, concrete, and hardware.

Fixed object attachments for guardrail will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing and installing guardrail connectors, rubrail, and additional posts with blockouts and providing holes to facilitate attachment.

Special design guardrail bridge attachments will not be measured for payment but will be paid for at the contract lump sum price per structure. This price shall include furnishing and installing terminal connectors and additional posts with blockouts.

Cable barricades will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing and installing posts, cable, signs, and padlocks.

When specified as a separate bid item, guardrail terminal site preparation will be measured in units of each per site and will be paid for at the contract unit price per each site.

The price for guardrail terminal site preparation shall include clearing and grubbing; providing, hauling, and placing fill material; benching existing slopes; and restoration of site including seeding.

These prices shall include excavating; backfilling holes; installing delineators; repairing damaged surfaces; furnishing, galvanizing, and erecting units; furnishing concrete anchor assemblies; and prebor-ing.

Bull nose barrier will be measured and paid for in units of each, complete-in-place, which price shall include furnishing and placing foundation soil tubes, concrete, polystyrene sheeting, welded wire fabric, posts, radial guardrail, blockouts, hardware, and delineators. This price shall be full compensation for all labor, materials, tools, and equipment necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
Guardrail (Standard)	Linear foot
Reuse guardrail (Standard)	Linear foot
Radial guardrail (Standard)	Linear foot
Guardrail terminal (Standard and type)	Linear foot or Each
Intermediate anchorage assembly	Each
Median barrier (Standard)	Linear foot
Radial median barrier (Standard)	Linear foot
Median barrier terminal (Standard and type)	Each
Cable barricade (Standard)	Each
Fixed object attachment (Standard)	Each
Special design guardrail bridge attachment (B or Str. No.)	Lump sum
Reuse guardrail terminal (Standard and type)	Linear foot or Each
Guardrail terminal site preparation (Standard)	Each
Bull nose barrier	Each

SECTION 506—RETAINING WALLS

506.01—Description

This work shall consist of constructing rubble and hydraulic cement concrete retaining walls in accordance with the plans and these specifications and in conformity to the lines and grades shown on the plans or as established by the Engineer.

506.02—Materials

- (a) **Dry rubble and mortar rubble retaining walls** shall be constructed of stone conforming to the requirements of Section 204 and mortar conforming to the requirements of Section 218.
- (b) **Hydraulic cement concrete retaining walls** shall be constructed of concrete conforming to the requirements of Section 217.
- (c) **Reinforced concrete crib walls** shall be constructed of precast concrete units. Concrete shall conform to the requirements of Section 217 except that No. 7 aggregate may be used in lieu of No. 57 aggregate. Crib units shall be free from cracks, depressions, spalls, patched or plastered surfaces or edges, and any other defects that might impair their strength or durability.
- (d) **Drain pipe** shall conform to the requirements of Section 232.02.
- (e) **Reinforcing steel** shall conform to the requirements of Section 223, Grade 40 or 60.
- (f) **Porous backfill** shall conform to the requirements of Section 204.02(c).
- (g) **Granular backfill within crib walls** shall be any material available within the project limits consisting of sand, sandy loam, gravel, rock, or a combination thereof. Materials containing a high percentage of fines, such as clay and silt soils, shall not be used.
- (h) **Piles** shall conform to the requirements of Section 403.

506.03—Procedures

Excavation, backfill, and foundation exploration shall conform to the requirements of Section 401.

Concrete construction shall be performed in accordance with the requirements of Section 404. Immediately following finishing operations, concrete shall be cured and protected in accordance with the requirements of Section 404.03.

- (a) **Dry Rubble and Mortar Rubble Retaining Walls:** Stones shall not be placed in freezing weather or when stone contains frost.

Each stone shall have a thickness of at least 8 inches; a width of at least 1 1/2 times the thickness; and, except for headers, a length at least equal to 1 1/2 times the width. The thickness of courses if varied shall diminish from the bottom to the top of the wall.

Header stones in the heart of the wall shall be the same size as in the face and shall extend at least 12 inches into the core or backing. They shall occupy at least 1/5 of the face area of the wall and shall be evenly distributed. Header stones in walls 2 feet or less in thickness shall extend entirely through the wall.

Stones shall be roughly squared on joints, beds, and faces. Selected stone, roughly squared and pitched to line, shall be used at angles and ends of walls.

Stones shall be placed to line and in courses roughly leveled. Bottom or foundation courses shall be composed of large, selected stones. Courses shall be placed with bearing beds parallel to the natural bed of the material.

Shaping or dressing of stone shall be performed before stone is placed in the wall. Dressing or hammering that will loosen the stone will not be permitted after placement.

1. **Dry rubble retaining walls:** Face joints shall be not more than 1 inch in width.

Each stone shall have a firm bearing on the underlying course at no fewer than three points. Open joints, both front and rear, shall be chinked with spalls fitted to take firm bearing on their top and bottom surfaces and shall have a firm bearing throughout the length of the stone.

2. **Mortar rubble retaining walls:** Each stone shall be cleaned and thoroughly wetted with water before it is placed, and the bed that is to receive it shall be cleaned and moistened. Stones shall be bedded in freshly prepared mortar. Mortar joints shall be full, and stones shall be carefully settled in place before mortar has set. Spalls will not be permitted in beds. Joints and beds shall not have an average thickness of more than 1 inch.

Whenever possible, face joints shall be properly pointed before mortar has set. Joints that cannot be pointed shall be prepared for pointing by raking them out to a depth of 2 inches before mortar has set. Face surfaces of stones shall not be smeared with mortar forced out of joints.

Vertical joints in each course shall offset joints with those in adjoining courses by at least 6 inches. A vertical joint shall not be located directly above or below a header.

If a stone is moved or a joint is broken, the stone shall be taken up, mortar shall be thoroughly cleaned from the bed and joints, and stone shall be placed in fresh mortar.

Joints that are not pointed at the time stone is placed shall be thoroughly wetted with clean water and filled with mortar. Mortar shall be driven into joints and finished with an approved pointing tool. The wall shall be kept wet while pointing is being done. In hot or dry weather, pointed masonry shall be protected from the sun and kept wet by saturated burlap for at least 3 days after completion.

After pointing is completed and mortar has set, the wall shall be thoroughly cleaned and left in a neat, orderly condition.

- (b) **Concrete Retaining Walls:** Concrete retaining walls shall be constructed in accordance with the requirements of Sections 403, 404, and 406.
- (c) **Reinforced Concrete Crib Walls:** Crib units that are damaged during erection shall be removed and replaced at the Contractor's expense.

Granular backfill shall be used inside and approximately 2 feet in back of and beyond each end of a crib. Backfilling for the crib wall shall follow closely the erection of successive tiers of units. The wall shall not be placed higher than 3 feet above the backfilled portion. Backfill shall be placed carefully to avoid distorting the crib wall.

506.04—Measurement and Payment

Standard retaining walls will be measured in cubic yards, complete-in-place, within the limiting dimensions shown on the plans, and will be paid for at the contract unit price per cubic yard. This price shall include rubble stone, concrete, joint material, and weep holes.

Concrete and reinforcing steel for special design retaining walls will be measured and paid for in accordance with the requirements of Sections 404.08 and 406.04, respectively.

Reinforced concrete crib walls will be measured in cubic feet of the net volume of concrete in crib units, complete-in-place, and will be paid for at the contract unit price per cubic foot. This price shall include concrete and reinforcing steel.

Granular backfill will be measured and paid for as regular excavation in accordance with the requirements of Section 303.06.

Porous backfill for retaining walls will be measured and paid for in accordance with the requirements of Section 401.04.

Piles for retaining walls will be measured and paid for in accordance with the requirements of Section 403.08.

Excavation for retaining walls will be measured in accordance with the requirements of Section 401.04 and will be paid for at the contract unit price per cubic yard. This price shall include excavation, foundation exploration, sheeting and shoring, placing and compacting backfill and disposal of surplus material, and porous backfill when not specified as a separate pay item.

Payment will be made under:

Pay Item	Pay Unit
Retaining wall (Standard)	Cubic yard
Concrete crib (Standard)	Cubic foot
Retaining wall excavation	Cubic yard

SECTION 507—FENCES

507.01—Description

This work shall consist of constructing and grounding new fence in accordance with these specifications and in conformity to the lines and grades shown on the plans or as established by the Engineer.

507.02—Materials

- (a) **Materials for fences** shall conform to the requirements of Section 242.
- (b) **Staples** shall be 9-gage galvanized strand wire and shall be at least 1 1/2 inches in length for soft wood posts and at least 1 inch in length for hardwood posts.
- (c) **Grounding materials** shall conform to the requirements of Section 238.

507.03—Procedures

Old fences that are not to be salvaged, trees, stumps, logs, and other debris that will interfere with new fence construction shall be removed and disposed of as directed by the Engineer.

If rock is encountered before the specified post depth is reached, posts shall be placed approximately 3 feet in depth or 18 inches into rock, whichever is less. The diameter of holes prepared for setting posts in rock shall be at least 3 inches greater than the larger cross-sectional dimension of the post. If rock is encountered during installation of gates, corners, or brace posts, posts shall be placed in concrete.

Except where rock is encountered, post and braced post anchor devices may be used in lieu of placing post and braces in concrete. Anchor devices shall be fabricated of steel having a yield strength of at least 30,000 pounds per square inch or of other metal approved by the Engineer; shall have a thickness of not less than that specified for the post or 1/8 inch, whichever is greater; and shall be galvanized in accordance with the requirements of Section 233.

Post and braced post anchor devices, together with the post, shall develop at least 80 percent of the resistance to horizontal and rotational displacement of individual post and braced post assemblies set in concrete when the load is gradually applied to the fence fabric at midheight. The Contractor shall demonstrate that the performance of post and braced post anchor devices will be comparable to that of concrete when such devices are proposed for use in lieu of concrete. The use of post and braced post anchor devices in lieu of concrete and the demonstration of comparable performance shall be at the Contractor's expense.

- (a) **Standard Chain Link Fences:** Metal posts for chain link fences shall be set in Class A3 concrete footings. Posts set in concrete footings shall not be disturbed for at least 7 days following the initial set of concrete and for at least 14 days when the average air temperature for the week following placement is below 50 degrees F.

Each span shall be attached independently at pull and corner posts. Ends of fabric rolls and other sections to be spliced shall be joined by weaving a single strand of the fabric wire into

ends of the fabric to create a continuous pattern of mesh. Fabric shall be stretched taut and securely fastened to each post and rail. Fastenings at ends, gates, corners, and pull posts shall be with stretcher bars and metal bands.

- (b) **Standard Fences:** Wood posts shall be set with the larger end down. Backfill around wood posts shall be thoroughly compacted in layers approximately 6 inches in thickness. Wood posts may be driven provided they are not damaged.

Metal posts shall be driven.

Wire shall be stretched taut and securely fastened to each post. Unless a splice can be provided that will develop a strength comparable to the strength of the wire, splicing will be permitted only at posts. Each horizontal strand of wire shall be wrapped around the end of the gatepost and securely fastened by winding it about the wire leading to the post.

A new fence shall be joined to an existing fence at the beginning and end of the new fence and at points where cross fences intersect the new fence.

Wood fence posts shall be installed so that the tops form a regular grade line. Tops or bottoms of posts that are sawed in the field shall be brush coated with three heavy applications of 2 percent copper naphthenate from the Department's approved product list. Each application shall be given sufficient time to penetrate the wood.

Gates shall be erected at locations shown on the plans or where designated by the Engineer. If preferred by the property owner and approved by the Engineer, gates and fences similar in type to those that exist may be substituted for the gate shown on the standard drawings.

Surplus excavated material and other debris resulting from erecting fences shall be removed, and the site shall be left in a neat, orderly condition.

The Contractor shall be responsible for damage caused to or by livestock straying through areas where an old fence has been removed and is to be replaced with a new fence.

- (c) **Pedestrian Fences for Bridges:** The frame for pedestrian fences for bridges shall be bonded internally to maintain continuity. Electrical grounding shall conform to the requirements of Section 410.03(b).
- (d) **Temporary Safety Fences:** The Contractor shall furnish and install a safety fence at required locations or as directed by the Engineer. The fence shall be no less than 4 feet high and colored bright orange polyethylene web and shall comply with the requirements of Section 242.02(a)12.

The safety fence shall be installed on metal "T" or "U" post spaced on 6-foot centers driven to a minimum depth of 18 inches.

The Contractor shall maintain the safety fence and remove it when no longer required.

507.04—Measurement and Payment

Fences will be measured in linear feet of fence fabric, complete-in-place, along the top of the fence from outside to outside of end posts for each continuous run of fence, exclusive of gates, and will be paid for at the contract unit price per linear foot of fence fabric. This price shall include clearing, leveling, and preparing terrain at the fence level; line posts; attaching to posts; grounding; and disposing of surplus and unsuitable material.

Line and corner braces will be measured in units of each and will be paid for at the contract unit price per each. This price shall include posts, braces, concrete, and dowels.

Water gates, Types I and II, will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each. This price shall include fittings.

Water gate, Type III, will be measured in linear feet of gate between inside edges of end posts, complete-in-place, and will be paid for at the contract unit price per linear foot. This price shall include end posts and anchor block assemblies.

Pedestrian fences will be measured along the top of the wall, complete-in-place, and will be paid for at the contract unit price per linear foot. This price shall include posts, fabric, braces, ties, and grounding.

Temporary safety fence will be measured and paid for in units of linear foot. This price shall include furnishing and installing the fence, metal post, maintenance, and removal when no longer required.

Payment will be made under:

Pay Item	Pay Unit
Fence (Standard)	Linear foot
Corner brace unit (Standard)	Each
Line brace unit (Standard)	Each
Pedestrian fence (Height)	Linear foot
Gate (Standard and length)	Each
Water gate (Standard)	Each or Linear foot
Temporary safety fence, 4 feet	Linear foot

SECTION 508—DEMOLITION OF PAVEMENT AND OBSCURING ROADWAY**508.01—Description**

This work shall consist of demolition of pavement and obscuring roadway to restore areas that are no longer needed for highway use in accordance with these specifications and in conformity to the lines and contours shown on the plans or as established by the Engineer.

508.02—Procedures**(a) Demolition of Pavement Structures:**

1. **Hydraulic cement concrete pavement** shall be demolished as follows:
 - a. Pavement shall be broken into pieces and either used in fill areas as rock embankment in accordance with the requirements of Section 303 or disposed of at locations selected by the Contractor and approved by the Engineer; *or*
 - b. Material within the proposed roadway prism and more than 3 feet below the subgrade may be broken into pieces not more than 18 inches in any dimension, sufficiently displaced to allow for adequate drainage, and left in the roadway prism.
2. **Asphalt concrete pavement** that does not overlay or underlie hydraulic cement concrete pavement shall be removed as follows:
 - a. Pavement shall be removed and used in the work as designated on the plans or as directed by the Engineer; *or*
 - b. When approved by the Engineer, pavement shall be removed and disposed of at locations selected by the Contractor.
3. **Cement-stabilized courses underlying pavement designated for demolition** shall be disposed of in accordance with (a)1.a. or (a)1.b. herein.
4. **Aggregate underlying pavement designated for demolition** except hydraulic cement concrete pavement disposed of in accordance with (a)1.b. herein shall be salvaged and used for maintenance of traffic or, when approved by the Engineer, disposed of in accordance with (a)2.a. herein.

(b) Obscuring Roadway:

1. **Areas outside construction limits consisting of asphalt concrete or hydraulic cement concrete pavement demolished in accordance with (a) herein** shall be conditioned in accordance with the following:
 - a. Tops of slopes that do not contain rock shall be rounded for a distance of not more than 10 but not less than 5 feet (where sufficient right of way exists) beyond the point of intersection of the existing slope and the natural ground surface. The depth of the rounding shall be not more than 2 feet below the original surface of slopes.
 - b. Disturbed areas that are to receive vegetation shall be scarified or plowed, harrowed, and shaped.
 - c. Clearing and grubbing shall be performed in accordance with the requirements of Section 301.
2. **Areas outside construction limits consisting of pavement structures, other than asphalt concrete or hydraulic cement concrete, that are designated for obscuring**

roadway shall be conditioned in accordance with (b)1. herein. Prior to the obscuring, pavement structures shall be removed in accordance with the applicable requirements of (a) herein.

508.03—Measurement and Payment

Demolition of hydraulic cement concrete pavement and shoulder structure courses or a combination thereof will be measured as demolition of pavement (rigid) and will be paid for in square yards based on the width of the widest course. Such price shall include all demolition, removal and disposal costs of pavement, base, subbase and stabilized subgrade materials.

Demolition of asphalt concrete pavement and shoulder structure courses or a combination thereof will be measured as demolition of pavement (flexible) and paid for in square yards based on the width of the widest course. Such price shall include all demolition, removal and disposal costs of pavement, base, subbase and stabilized subgrade materials.

Demolition of a combination of hydraulic cement concrete pavement and asphalt concrete pavement and shoulder structure courses or a combination thereof will be measured as demolition of pavement (combination) and paid for in square yards based on the width of the widest course. Such price shall include all demolition, removal and disposal costs of pavement, base, subbase and stabilized subgrade materials.

Obscuring roadway will be measured in units of 1,000 square feet computed to the nearest 1/10 unit and will be paid for at the contract unit price per unit. The area measured will be entirely outside the construction limits of the new roadway, as evidenced by slope stakes. Areas disturbed by the operations, including tops of slopes to be rounded, will be included in the measurement. Removing pavement structures other than hydraulic cement–stabilized, hydraulic cement concrete, and asphalt concrete pavement structures in accordance with (b) 2. herein will be measured as regular excavation in accordance with the requirements of Section 303 or as lump sum grading on minimum plan and no plan projects. Clearing and grubbing will be paid for in accordance with the requirements of Section 301.

Payment will be made under:

Pay Item	Pay Unit
Demolition of pavement	Square yard
Obscuring roadway	Unit
Demolition of pavement (Type)	Square yard

SECTION 509—PATCHING HYDRAULIC CEMENT CONCRETE PAVEMENT

509.01—Description

This work shall consist of removing designated areas of defective hydraulic cement concrete pavement and unstable subbase material, replacing subbase material where required, and replacing pave-

ment with high-early-strength hydraulic cement concrete in accordance with these specifications and in conformity to the original lines and grades or those established by the Engineer.

509.02—Materials

- (a) **Hydraulic cement concrete** shall conform to the requirements of Section 217 for Class A3 paving concrete except that the compressive strength shall be at least 3,000 pounds per square inch within 24 hours. The accelerated strength gain shall be achieved by the use of 800 ± 50 pounds per cubic yard of Type III cement conforming to the requirements of AASHTO M-85 and approved air-entraining, accelerating, and water-reducing admixtures conforming to the requirements of Section 215. If calcium chloride is permitted as an accelerating admixture, it shall be limited to 2 percent by weight. The air content shall be 6 ± 2 percent. The water/cement ratio shall be not more than 0.42 by weight.

The Contractor shall prepare a sufficient number of trial batches in the presence of the Engineer to verify the strength and workability of the mixture design when required. The continued adequacy of the mixture design and minimum compressive strength will be verified monthly by the Engineer.

- (b) **Asphalt concrete** shall conform to the requirements of Section 211 except that material may be accepted by certification and visually inspected at the job site.
- (c) **Subbase material** shall conform to the requirements of Section 208.
- (d) **Preformed asphalt joint filler and joint sealer** shall conform to the requirements of Section 212.
- (e) **Curing material** shall conform to the requirements of Section 220.
- (f) **Reinforcing steel** shall conform to the requirements of Section 223.

509.03—Procedures

Where the existing joint dowel assembly is to be removed, existing concrete shall be saw cut and removed at least 1 foot on each side of transverse joints. Undisturbed portions of pavement adjacent to the area to be patched shall be left with straight, vertical sides. In areas from which concrete has been removed, the subbase shall be dressed, brought to grade, and mechanically compacted. Dowels and assemblies shall be removed and disposed of off the project.

Saw cuts shall not extend into adjacent concrete pavement except when repairs are to be extended at that location. Saw cuts shall be straight, neat, vertical, and parallel or perpendicular to the centerline as required.

Unsuitable subbase shall be removed, disposed of, and replaced in accordance with the requirements of Section 307 or 308, whichever is applicable. Where soil cement subbase is present and sound, excavation below the top of the soil cement line and under adjacent slabs will not be required.

Preformed asphalt joint filler shall be installed in accordance with the requirements of Section 316.04(g)2.

Joint material and reinforcing steel shall be placed in accordance with the following:

1. **Patches less than 10 feet in length:** Preformed asphalt joint filler shall be placed flush against the run-off side of the adjacent pavement.
2. **Patches greater than 10 feet in length:** Preformed asphalt joint filler shall be placed flush against sides of the adjacent pavement.
3. **Patches 20 feet in length or greater:** Patches shall conform to the requirements of the applicable reinforced concrete pavement standards.
4. **Load transfer devices used in initial construction:** Load transfer devices shall be left intact, straightened, and used for tying in the replaced slab or shall be replaced with an approved load transfer device.
5. **Joints:** Rounded or beveled transverse joints shall be provided adjacent to the undisturbed pavement to allow installation of sealant at a depth of at least 1/4 but not more than 1/2 inch.

The excavated area shall be thoroughly cleaned and moistened before concrete is placed.

Full-depth forms shall be of sufficient strength to support plastic concrete without deformation.

Existing pavement shall not be removed if removal will result in concrete being placed when the air temperature is below 55 degrees F. The concrete temperature at the time of placement shall be at least 70 degrees F but not more than 95 degrees F.

Concrete shall be placed on the subgrade and consolidated so that it fills the area of the patch. Concrete shall be finished in accordance with the requirements of Section 316.04(h) except that the final surface shall have a texture similar to that of the adjoining pavement.

As soon as concrete is finished and prior to its initial set, the patch and existing pavement for a distance of 8 feet shall be tested by means of a 10-foot straightedge placed parallel to the centerline of the road surface. Irregularities in the patch in excess of 1/4 inch shall be corrected.

Immediately after it has been textured, concrete shall be covered with wet burlap and PE film. An insulating blanket shall be placed over the PE film whenever the air temperature is below 65 degrees F during the curing period. Curing shall continue until immediately before opening to traffic but will not be required beyond 24 hours.

Transverse joints at pavement repair locations shall be cleaned and resealed in accordance with the requirements of Section 316.04(m).

Asphalt concrete shoulders that are damaged during repair operations shall be reconstructed within 24 hours after completion of a patch in accordance with the requirements of Section 315 with full-depth SM-12.5A asphalt concrete to match the finished grade. If traffic is to be permitted on the patch prior to reconstruction of the shoulder, the shoulder shall be temporarily repaired to prevent any hazardous condition.

Traffic shall be maintained in accordance with the requirements of Section 512 or as directed by the Engineer.

509.04—Measurement and Payment

Patching hydraulic cement concrete pavement will be measured in square yards of pavement surface area, complete-in-place, and will be paid for at the contract unit price per square yard. This price shall include saw cutting pavement full depth; removing and disposing of existing concrete; preparing subgrade; furnishing and installing preformed asphalt joint filler; placing, finishing, and curing special design concrete; trial batches; cleaning and resealing joints; repairing shoulders; sealing joints; and reinforcing steel.

Payment will be made under:

Pay Item	Pay Unit
Patching hydraulic cement concrete pavement	Square yard

SECTION 510—RELOCATING OR MODIFYING EXISTING MISCELLANEOUS ITEMS

510.01—Description

This work shall consist of removing, resetting, relaying, adjusting, installing, modifying, reconstructing, or relocating existing items or items furnished by the Department or others, including, but not limited to, right-of-way monuments, guardrail, riprap, drainage structures, traffic control devices, water or sanitary sewer facilities, and other items designated on the plans.

510.02—Materials

The principal materials to be used in this work shall be those salvaged.

Items shall be constructed, adjusted, modified, or reconstructed with the same type of material as used in the original construction.

The suitability of existing material for salvage, modification, or reuse will be determined by the Engineer.

New, salvaged, or refurbished materials necessary for resetting, relaying, adjusting, modifying, or relocating the item specified shall conform to the requirements of the applicable specifications for items of the same character and type. Salvaged or refurbished materials shall be in good working condition, which shall include cleaning, repainting, and refinishing to the approximate original condition.

510.03—Procedures

Materials designated for salvage shall be carefully removed, dismantled, cleaned, and stockpiled in areas where they will not be damaged or shall be delivered to the storage area. Material that is not designated for salvage shall be disposed of in an approved disposal area. Items designated for relocation,

510.03

relaying, adjustment, modification, or installation shall be installed in accordance with the applicable specifications or as directed by the Engineer.

510.04—Measurement and Payment

Removing, resetting, relaying, adjusting, installing, modifying, reconstructing, or relocating designated items will be measured by the unit specified in the Contract in accordance with the plans and the applicable sections of these specifications and will be paid for at the contract unit price for the specified item. This price shall include loading, unloading, and transporting furnished materials; cleaning, repainting, and refinishing salvaged items; removing, resetting, relaying, adjusting, installing, modifying, reconstructing, or relocating designated items; salvaging or disposing of surplus and unsuitable material; excavating; trenching; backfilling; preparing foundation; reconnecting components for electrical and electronic items; revising wiring diagrams or schematics; and restoring disturbed areas.

Payment will be made under:

Pay Item	Pay Unit
Remove, reset, relay, adjust, install, modify, reconstruct, relocate existing (Item or standard)	Each, Linear foot, Square yard, Cubic yard, or Lump sum

SECTION 511—ALLAYING DUST

511.01—Description

This work shall consist of applying either moisture, calcium chloride, or both on areas designated by the Engineer for the purpose of allaying dust.

511.02—Procedures

The Contractor shall furnish a truck(s) equipped with a water tank having a capacity of at least 1,000 gallons and pumps for furnishing, loading, and applying water to the roadway.

Equipment and operators shall be available at all times.

Calcium chloride conforming to the requirements of Section 239 shall be applied at the rate specified on the plans or by the Engineer.

The Contractor shall plan and prosecute the work so as to expedite completion of the pavement structure as soon as is practicable.

511.03—Measurement and Payment

Allaying dust will be measured and paid for on the basis of the time the truck is in service on this work or per ton of calcium chloride. Loading time allowed for payment shall be not more than 30 minutes per 1,000 gallons of water. Truck hours shall be evidenced by daily time reports submitted by the Contractor and approved by the Engineer. This price shall include water and calcium chloride.

When in-place base material is used as a riding surface to maintain traffic or as a haul route, truck hours or tons of calcium chloride used for allaying dust will be paid for in accordance with the provisions herein.

Payment will be made under:

Pay Item	Pay Unit
Allaying dust	Hour or Ton

SECTION 512—MAINTAINING TRAFFIC

512.01—Description

This work shall consist of maintaining and protecting traffic through areas of construction, maintaining public and private entrances and mailbox turnouts, constructing and obliterating detours, and protecting the traveling public within the limits of the project and over detours that are not a part of the state highway system in accordance with the contract documents.

512.02—Materials

- (a) **Materials** salvaged from the roadway shall be used in the maintenance of traffic insofar as possible. Material shall conform to the requirements of the applicable specifications.
- (b) **Signalization, barricades, channelizing devices, safety devices, and pavement markings** shall conform to the requirements specified in Division VII, Traffic Control Devices, and the *Virginia Work Area Protection Manual* except where otherwise indicated. Retroreflective surfaces shall conform to the requirements of Sections 235, 247, and 702, as applicable.
- (c) **Temporary pavement markers** shall conform to the requirements of Section 235.
- (d) **Construction pavement markings** shall conform to the requirements of Section 246.
- (e) **Construction signs** shall conform to the requirements of Section 247. Sign substrates for rigid construction signs mounted on posts shall conform to the requirements of Section 701 or be a 0.079-inch-thick aluminum/plastic laminate.

Sign substrates for signs mounted on drums, Type III barricades, and portable sign stands shall be of the materials as specified in the charts that follow and shall be the same material that was used when the device was tested and found to be in compliance with the require-

ments of *National Cooperative Highway Research Program (NCHRP) Report 350*, Test Level 3, or of other materials allowed in the FHWA acceptance letter.

Sign Substrates for Type III Barricades and Portable Sign Stands

Rollup sign

0.4-inch-thick corrugated polypropylene or polyethylene plastic

0.079-inch-thick aluminum/plastic laminate

Sign Substrates for Drums

0.4-inch-thick corrugated polypropylene or polyethylene plastic

512.03—Procedures

Traffic shall be maintained and protected in accordance with the requirements of Section 105.14. Work shall be scheduled and performed so as to provide minimum interference with and maximum protection for traffic. The Contractor's personnel, equipment, machinery, tools, and supplies shall be kept outside the clear zone and clear of active traffic lanes except as necessary for prosecuting active work. Stabilized construction entrances shall be used in construction areas where there is a potential for construction vehicles to track material from the construction site onto a paved surface. Material that is spilled or tracked onto the traveled pavement during prosecution of the work shall be promptly removed.

The Contractor shall maintain the traffic control devices, which shall include, but not be limited to, repositioning of displaced devices including traffic barrier service, replacement due to inadequate structural integrity including traffic barrier service, replacement due to loss of reflectivity, repair of defaced sheeting and legend, replacement of broken supports, repositioning of leaning signs so they are plumb and the sign face is perpendicular to the pavement edge, cleaning of dirty devices, and replacement of stolen or vandalized devices. Barricades, barriers, and other safety devices shall be inspected at least daily, and deficiencies shall be immediately corrected. Safety and protective devices furnished by the Contractor will remain the property of the Contractor and shall be removed from the project site upon completion of the work or as directed by the Engineer.

- (a) **Signs:** The Contractor shall furnish and install temporary sign panels necessary for the project, which shall include, but not be limited to, maintenance of traffic, beginning and end of construction, and off-project detour signing.

Signs and their placement shall conform to the requirements of the *Virginia Work Area Protection Manual*, the *MUTCD*, and the plans and as directed by the Engineer. The Contractor shall submit to the Engineer a sketch of his proposed construction sign layout for approval prior to installation. The Contractor shall furnish supports, i.e., wood posts and barrier and wall attachments, and hardware for use with the temporary sign panels. In lieu of using wood posts, the Contractor may request permission from the Engineer to use alternate products on the Special Products Evaluation List. The request shall contain all information related to the manufacturer's installation requirements, including but not limited to, post spacing and the square footage of sign panel the product can support based on AASHTO's requirements for a wind speed of 60 miles per hour. The Contractor shall be responsible for covering, uncovering, or removing and reinstalling existing signs that conflict with the signs needed for maintenance of traffic. Covering of existing signs shall be accomplished in ac-

cordance with the requirements of Section 701.03(d). The Contractor shall furnish and install flags for the temporary sign panels as directed by the Engineer except flags will not be required for use on portable sign supports. Signs shall be installed and attached to wooden supports in accordance with Standard WSP-1 of the Department's *Road and Bridge Standards*. The size and number of wooden supports shall be in accordance with the standard drawings. When alternate products for supports are approved for use by the Engineer, the supports, including size and number, and signs shall be installed in accordance with the manufacturer's recommendation.

Retroreflective flexible sign base materials conforming to the requirements of Section 247 for material that is not Type VI material may be used both day and night up to a maximum of three continuous days.

The Contractor may furnish portable sign stands for mounting temporary sign panels in accordance with the following:

1. Sign installations shall be used for no longer than 3 consecutive days.
2. Portable sign stands shall be used with signs having a substrate material of the type required in Section 512.02(e) and only those that were tested and found to be in compliance with the requirements of *NCHRP Report 350*, Test Level 3, or otherwise accepted in an FHWA acceptance letter for the specific sign stand.

Portable sign stands shall conform to the requirements of *NCHRP Report 350*, Test Level 3, and shall be selected from those shown on the Department's Approved List or the Contractor shall submit a certification letter submitted prior to their use stating the brands and models of portable sign stands to be used along with a copy of the FHWA acceptance letter indicating compliance with *NCHRP Report 350*, Test Level 3. Portable sign stands shall be self-erecting and shall accommodate signs of the shape being used. Portable sign stands shall support a 16-square-foot sign panel in sustained winds of 50 miles per hour without tipping over, walking, or rotating more than ± 5 degrees about its vertical axis. Additional weight consisting of no more than one 25-pound sandbag placed on each leg or no more than two cone weights positioned on the center of the sign stand and around the mast may be used to comply with this requirement. When used on uneven surfaces, the portable sign stand shall be capable of adjusting to those surfaces to allow the signs to be installed in their normal upright position ± 15 degrees. Portable sign stands shall include decals, stenciling, or other durable marking system that indicates the manufacturer and model number of the stands. Such marking shall be of sufficient size so it is legible to a person in a standing position.

The Contractor shall erect, maintain, move, and be responsible for the security of sign panels and shall ensure an unrestricted view of sign messages for the safety of traffic.

When construction signs are covered to prevent the display of the message, the entire sign shall be covered with silt fence or other materials approved by the Engineer such that no portion of the message side of the sign shall be visible. Plywood shall be used on ground-mounted construction signs only. Attachment methods used to attach the covering material to the signs shall be of a durable construction that will prevent the unintentional detachment of the material from the sign. At no times shall a construction sign and/or post be rotated to prevent the display of the message. In addition, the posts where the signs are being covered shall have two ED-3 Type II delineators mounting vertically on the post below the

signs at a height of 4 feet to the top of the topmost delineator. The bottom delineator shall be mounted 6 inches below the top delineator.

- (b) **Flagger Service and Pilot Vehicles:** The Contractor shall provide flagger service in accordance with the requirements of Section 105.14(c).

When one-way traffic is approved, the Contractor shall provide flagger service and, where necessary, pilot vehicles to maintain traffic. Each vehicle shall be equipped with at least one roof-mounted rotating amber flashing light and shall display required signs while in service.

Portable traffic control signals conforming to the requirements of Section 512.03(h)2 may be used in lieu of flagger service when specified or approved by the District Traffic Engineer. When portable traffic control signals are used in lieu of flagger service, the portable traffic control signals will be measured and paid for separately.

- (c) **Electronic Arrows:** Electronic arrows shall be electronic flashing or sequential amber arrows having dimmer controls and shall be mounted on suitable trucks or trailers. The Contractor shall maintain and move electronic arrows as needed for traffic control.

Trailers supporting arrow boards and the boards themselves shall be either Virginia highway orange (DuPont Color No. LF74279 AT or color equivalent) or federal yellow in color. The trailer's back frame shall have 2-inch-high retroreflective sheeting conforming to the requirements of Section 247.02(c) installed on the area facing traffic. The sheeting shall have alternating 11-inch-wide vertical red stripes and 7-inch-wide vertical white stripes.

- (d) **Warning Lights:**

1. **Type A flashing lights** shall be used for advance warning signs and hazardous locations and shall be in operation during hours of darkness and low visibility. A Type A flashing light shall be installed on concrete traffic barrier service at the break point between the transition and tangent sections.
2. **Type B flashing lights** shall be used when specified on the plans for advanced warning signs and extremely hazardous locations and shall be in operation at all times.
3. **Type C steady burn lights** shall be used when specified on the plans for channeling traffic and may be placed on Group 2 channelizing devices. When used on Group 2 channelizing devices, the channelizing devices shall have been tested with the light and an FHWA acceptance letter issued indicating compliance with *NCHRP Report 350*, Test Level 3, as required in (e) herein. Lights shall be placed at intervals of 80 feet along tangent sections and 40 feet along bridges, transitions, and curves greater than 6 degrees. Lights shall be in operation from 30 minutes before sunset until 30 minutes after sunrise, on heavy overcast days, in fog, and during periods of darkness or low visibility as directed by the Engineer.

- (e) **Channelizing Devices:** Channelizing devices shall conform to the requirements of *NCHRP Report 350*, Test Level 3, Channelizing devices shall be selected from those shown on the Department's Approved List beginning with the applicable purchasing dates. The Contractor shall provide a certification letter stating the brands and models of channelizing devices contained on the listing that will be used. In lieu of using channelizing devices on that listing, the Contractor may use other brands and/or models conforming to the specification re-

quirements provided he submits catalog cuts/brochures of each brand and model prior to their use and complies with the following requirements:

1. **Channelizing devices except drums/cones with an auxiliary device attached and portable vertical panel assemblies:** A copy of a letter from the manufacturer certifying that the specific channelizing device is crashworthy, i.e., that it will comply with the evaluation criteria specified in *NCHRP Report 350*. This certification may be a one-page affidavit signed by the manufacturer.
2. **Drums/cones with an auxiliary device attached, and portable vertical panel assemblies with or without an auxiliary device attached:** A copy of the FHWA acceptance letter indicating compliance with *NCHRP Report 350*, Test Level 3 shall be submitted.

The Contractor shall provide, when applicable, a certification letter indicating that the channelizing devices being used that are not on the Department's Approved List and for which no catalog cuts/brochures and self-certification are being supplied were purchased prior to October 2, 1998, or October 2, 2000, as applicable.

Spacing of channelizing devices shall be in accordance with the *Virginia Work Area Protection Manual*.

- a. **Group 1 devices** shall consist of tubular delineators or cones approximately 36 inches in height for interstate and other limited access roadways and approximately 28 inches in height for other roadways. They shall be used as temporary channelizing devices. When used during hours of darkness, they shall be provided with reflectorized collars or sleeves.
- b. **Group 2 devices** shall be drums or vertical panels. Drums shall be round, or partially round with no more than one flat side; made from plastic; have a minimum height of 36 inches, have a cross-sectional width no less than 18 inches in any direction; and conform to the requirements of the *Virginia Work Area Protection Manual*. Drums shall be designed to allow for separation of ballast and drum upon vehicular impact but not from wind and vacuum created by passing vehicles. Drums of two-piece design, i.e., drum and associated base, shall utilize sufficient amounts of enclosed sand at the base in accordance with the manufacturer's recommendations to provide stable drum support. The base shall be not greater than 5 inches in height. Two-piece drums may also utilize a flared drum foundation and collar of not more than 5 inches in height and of suitable shape and weight to provide stable support. One-piece drums may be used provided they comply with these above requirements.

Vertical panels shall be mounted on posts conforming to the requirements of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*.

Vertical panels will be allowed only for use in locations indicated in the contract documents. Non-portable vertical panels shall be mounted on posts conforming to the requirements of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*.

Open-top drums will not be allowed. Markings on drums shall be horizontally circumferential, alternating from the top of the drum, with orange and white 6-inch-wide retroreflective stripes. Each drum shall have a minimum of two orange and two white stripes, and the top stripe shall be orange. Any non-retroreflective areas on the drum except the base shall be orange, and spaces between retroreflective stripes shall not exceed 2 inches in width.

The Contractor shall furnish and install signs (Stop, chevron, Keep Right, etc.) for the drums as directed by the Engineer. Sign panels used on drums tested for conformance with NCHRP 350, Test Level 3 requirements shall be of the same material as that used for the test except that materials as allowed by the FHWA acceptance letter may be used when approved by the Engineer.

- (f) **Traffic Barrier Service:** Barrier service shall be of sufficient length to protect traffic and personnel in construction areas.

The Contractor shall continuously prosecute the work until completion once a barrier is in place. If the Contractor does not, the Engineer may cause him to discontinue operations in other areas on the project and concentrate efforts behind the traffic barrier service. When construction work is completed to the extent that traffic barrier service is no longer required as determined by the Engineer, devices shall be removed.

Neither workers nor equipment shall traverse areas confined by traffic barrier service and travel lanes except as approved by the Engineer and then only with adequate flagger service to safeguard workers and traffic in advance of and at the point the traffic barrier service is opened. Barrier openings for construction access may be provided only along tangent sections or along the inside of curved sections and shall be limited to the minimum length required for equipment access. The normal pavement alignment at the barrier opening shall be maintained with removable pavement marking. At ingress openings, the exposed end of the barrier service shall be provided with a temporary impact attenuator as approved by the Engineer. At egress openings, the exposed end shall be transitioned as dependent on the posted speed for traffic. The transition flare rate shall comply with the requirements of the *Virginia Work Area Protection Manual*. For speeds below 30 miles per hour, the transition flare rate shall be the same as that indicated for 30 miles per hour. An impact attenuator will not be required at the exposed end of egress openings in barrier service provided the deflection angle between the pavement edge and ends of the barrier service openings is 20 degrees or more.

Delineators shall be installed on traffic barrier service in accordance with the requirements of Section 702. Barrier vertical panels shall be installed on top of the concrete barrier service. Reflectorized sheeting shall comply with the requirements of Section 247. Design and installation of barrier vertical panels shall comply with the requirements of the *Virginia Work Area Protection Manual*.

The Contractor shall maintain the structural integrity of the barrier and its alignment while it is in use and shall maintain warning lights, delineators, and other devices in a clean and visible condition at all times.

1. **Guardrail barrier service and terminal treatments** shall be installed in accordance with the requirements of Section 505 except that the offset distance shall be as specified by the Engineer. The Contractor may reuse guardrail used for traffic barrier ser-

vice guardrail for permanent installation provided the guardrail material conforms to the requirements of Section 505 and the standard drawings and is acceptable to the Engineer. Marred galvanized surfaces shall be repaired in accordance with the requirements of Section 233.

2. **Concrete barrier service** shall be installed in accordance with the plans and standard drawings or as directed by the Engineer. When barrier terminates at a guardrail, fixed object attachments connecting the barrier to the guardrail shall be installed in accordance with the applicable standard for fixed object attachment. Installation shall include additional guardrail posts and attachments as required. Concrete barrier connections shall be snug to prevent motion between sections.

Precast concrete parapet for precast concrete parapet traffic barrier service shall be anchored as shown on the plans. Anchor holes in bridge decks shall be drilled with a rotary impact drill or other approved equipment that will prevent damage to the deck. Anchor holes shall be located so as to avoid cutting reinforcing steel. Upon removal of the parapet, anchor holes shall be cleaned and filled with Type EP-4 or EP-5 epoxy mortar conforming to the requirements of Section 243.

Parapet used for concrete parapet traffic barrier service will not be permitted for permanent installations on bridge structures.

The Contractor shall visually inspect all traffic barrier service shipped to a project prior to placing it in use. Concrete barrier sections shall be structurally sound with no concrete missing along the top, bottom, sides, or end sections of the barrier; no through cracks; and no exposed rebar. Any traffic barrier service found by the Contractor or Engineer to be unacceptable due to inadequate structural integrity or functionality shall be promptly removed from the project site and replaced at no cost to the Department. Traffic barrier service shall be selected from those shown on the Department's Approved List, except that the Contractor may use other traffic barrier service provided he submits a copy of the FHWA acceptance letter indicating compliance with *NCHRP Report 350* prior to it being used.

The Contractor shall maintain the structural integrity of the barrier and its alignment while it is in use and shall maintain warning lights, barrier vertical panels, delineators, and other devices in a clean and visible condition at all times. Concrete barrier service shall be cleaned or coated sufficiently to afford good visibility and uniformity of appearance.

- (g) **Impact Attenuator Service:** Impact attenuator service shall be installed at locations shown on the plans or designated by the Engineer. A modified Type III object marker shall be installed on impact attenuators.
- (h) **Temporary Signalization:** When specified on the plans, the Contractor shall install and maintain temporary or portable traffic control signal equipment. The Contractor shall submit to the Engineer a plan for locating, installing, and maintaining signals that shall depict the Contractor's intent for maintaining traffic flows during construction operations, including type of vehicle detection, phase sequencing, and timings. The Contractor shall receive acceptance of the plan from the Engineer prior to beginning work that would necessitate installing the proposed temporary or portable traffic control signals. The Contractor's design shall conform to the requirements of the applicable sections of *AASHTO's 1994 Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*; *MUTCD*; and the *Virginia Work Area Protection Manual*. Existing traffic control signal

equipment materials on the project may be used. New, salvaged, or refurbished traffic control signal equipment materials brought to the project shall conform to the contract specifications and standards.

1. **Temporary traffic control signals** shall conform to the following: the controller, accessory, auxiliary, and conflict monitoring equipment shall conform to the requirements of NEMA TS-1, NEMA TS-2, or as approved by the Engineer.
2. **Portable traffic control signals** shall conform to the following:
 - a. phase sequencing, timings, and conflict monitoring complying with NEMA TS-1 (Functional Standards).
 - b. 5 programmable day programs within a 24-hour period.
 - c. 12-inch traffic signal head sections with backplates mounted in the vertical display arrangement.
 - d. vehicular detection that will detect all licensed vehicles unless otherwise indicated in the contract documents.
 - e. adequate safeguards to prevent unauthorized entry to the control equipment.
 - f. trailer-mounted type with at least one of the two traffic signal heads positioned over the travelway with a minimum 16 feet of clearance from the pavement to the lowest point of the signal head assembly.
 - g. operate from its own self-contained power supply with the capability of connecting to an external 110-VAC electrical power supply. When operating from a self-contained solar power supply, the battery backup shall be capable of operating for 18 continuous days at 77 degrees F without solar array assist.
 - h. back frame of trailer with 2-inch-high reflective sheeting conforming to the requirements of Section 247.02(c) installed on the area facing traffic; sheeting shall have alternating 11-inch-wide vertical red stripes and 7-inch-wide vertical white stripes.
 - i. designed to comply in the operating mode with loading conditions associated with wind gusts of 80 miles per hour as specified in *AASHTO's 1994 Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*.

Temporary and portable traffic control signals that are not specified on the plans but are installed by the Contractor for his convenience shall be installed at the Contractor's expense and shall be approved through the process specified herein.

Maintenance and operation of temporary and portable traffic control signals shall be the responsibility of the Contractor and shall be in accordance with the requirements of Section 703.03(a).

When required, the Contractor shall make arrangements with the local utility company for electrical service for new temporary and portable traffic control signals, which shall include the costs of connection, disconnection, and energy. If electrical service is not available, the Contractor shall provide a generator capable of continuously operating the temporary and portable traffic control signals for at least 24 hours unassisted. The Contractor shall demonstrate the signal's operational procedures and reliability to the Engineer for approval prior to beginning work necessitating use of the signal equipment.

- (i) **Construction Pavement Markings:** Construction pavement markings shall be installed at locations shown on the plans and in the *Virginia Work Area Protection Manual* and at other locations as directed by the Engineer. Construction pavement markings shall be selected from the Department's Approved List of Construction Pavement Marking Materials. Construction pavement markings are classified as Type D, Classes I and II (removable tape); Type E (non-reflective black removable tape); and Type F, Classes I and II (temporary markings). Construction pavement markings shall be used as follows:
1. **Type D construction pavement markings** shall be used on final roadway surfaces or in areas where traffic patterns are subject to change before pavement is resurfaced unless the surface temperature of the pavement is below the pavement marking minimum application temperature recommended by the manufacturer. When the surface temperature of the pavement is below the manufacturer's minimum application temperature, a Type F construction pavement marking on the approved list under the same class as the specified Type D construction pavement marking may be used except on final surfaces. The Contractor shall select a Type F product known to perform the best under those temperature conditions. When a Type F construction pavement marking is used in lieu of a Type D construction pavement marking due to the surface temperature being below the manufacturer's minimum application temperature, the Contractor will be paid the price bid for Type D, which will include the Type F markings and any necessary eradication of existing pavement markings.
 2. **Type E construction pavement markings** shall be used to cover existing markings in accordance with (j) herein.
 3. **Type F construction pavement markings** shall be used where the roadway is to be resurfaced prior to changes in the traffic pattern or where pavement is to be demolished and traffic patterns will not change before demolition.

Construction pavement markings shall be installed in accordance with the manufacturer's recommendations. Application thickness and bead application shall comply with the manufacturer's recommendations except as follows. In the event the manufacturer's recommendation for material thickness and quantity of beads is less than that used when the material was tested by the National Transportation Product Evaluation Program (NTPEP), the minimum values used during product installation shall conform to the NTPEP test values that are indicated on the approved list for the specific marking. The Contractor shall furnish a copy of the manufacturer's installation recommendations including the thickness, bead embedment, and dispersment to the Engineer.

The Contractor shall maintain the construction pavement markings and shall correct any deficient markings by reapplying markings. Deficient construction pavement markings are considered to be any markings that do not provide adequate guidance to motorists due to inadequate retroreflectivity or color qualities or due to problems with

adherence to the pavement. The Engineer will make a visual nighttime inspection of all construction pavement markings to identify areas of markings that have inadequate retroreflectivity qualities.

Those markings that have inadequate retroreflectivity qualities as determined by the Engineer shall be replaced by the Contractor with the following exceptions:

- a. Reapplication of skip line construction pavement markings is not required unless the inadequate retroreflectivity qualities are for at least two consecutive skip lines.
- b. Reapplication of center; line, except skip lines; or edge line construction pavement markings is not required unless the inadequate retroreflectivity qualities are for at least a continuous section of 70 feet.
- c. Reapplication of transverse markings is not required unless the inadequate retroreflectivity qualities are for at least a continuous section exceeding 3 feet.

In lieu of replacement of construction pavement markings based on visual observations by the Engineer, the Contractor may have retroreflectivity readings made. These measurements shall be taken within 48 hours after the Contractor has been notified of the deficient markings except additional time will be granted due to inclement weather that prevents the adequate measurement of the markings. The Contractor shall brush any form of debris from the line before performing the measurements. Measurements shall be taken in the presence of the Engineer using Contractor-furnished equipment conforming to the requirements of ASTM E 1710. The Contractor shall operate the equipment in accordance with the manufacturer's instructions, and a copy of such instructions shall be provided to the Engineer. The photometric quantity to be measured is the coefficient of retroreflected luminance (R_L), which shall be expressed as millicandelas per square foot per footcandle. Measurements shall be taken at three random locations within each area of markings that have inadequate retroreflectivity qualities. When the length of the visually inadequate area is greater than 1 mile, measurements shall be taken at three locations per mile segment or portion thereof. Measurements for all lines shall be taken in the middle of the line horizontally. Measurements for skip lines shall be taken in the middle of their length. Measurements for transverse lines shall be taken outside of the wheel path locations. The Engineer will designate the locations along the line segments where the measurements shall be taken. The Contractor shall make a log of the measurements and their locations and provide a copy to the Engineer. When the average of the three readings for an area is below 100 millicandelas per square foot per footcandle, the Contractor shall reapply the markings as indicated.

Construction pavement markings that no longer adhere to the pavement shall be reapplied by the Contractor with the following exceptions:

1. Reapplication of skip line construction pavement markings is not required unless the markings do not adhere for at least two consecutive skip lines.
2. Reapplication of center; lane, except skip lines; or edge line construction pavement markings is not required unless the markings do not adhere for at least a continuous section of 70 feet.

3. Reapplication of transverse markings is not required unless the markings do not adhere for at least a continuous section exceeding 3 feet.

However, all construction pavement markings that no longer adhere to the roadway that may cause guidance problems for motorists shall be removed by the Contractor.

Removable construction pavement markings shall be replaced on time frames as recommended by the manufacturer of the marking to prevent the need for eradication. The Contractor shall furnish a copy of the manufacturer's recommendations to the Engineer.

Those construction pavement markings found in need of reapplication in accordance with these requirements shall be reapplied by the Contractor at no additional cost to the Department with the following exceptions:

- a) Markings that have been under traffic for more than 90 days will be paid for at the contract unit price when needing reapplication unless the manufacturer's warranty coverage is still in effect.
- b) Markings damaged by the Department's snow removal or other maintenance and construction operations will be paid for at the contract unit price.

Construction pavement markings shall be replaced in accordance with the time requirements of Section 704.

Eradication for reapplication of Type F construction pavement markings is not required if allowed by the marking manufacturer provided the existing marking is well adhered and the total thickness of the existing and reapplied marking combined will not exceed 40 mils. If not well adhered, 90 percent of the existing markings shall be removed prior to reinstallation of the markings.

Temporary pavement markers shall be installed with construction pavement markings in accordance with (k) herein.

- (j) **Eradicating Pavement Markings:** Markings that may conflict with desired traffic movement, as determined by the Engineer, shall be eradicated as soon as is practicable: either immediately prior to the shifting of traffic or immediately thereafter and prior to the conclusion of the workday during which the shift is made.

Eradication shall be performed by grinding, blasting, or a combination thereof. Grinding shall be limited to removal of material above the pavement surface except when removing thermoplastic and preformed tape markings, which may be removed by grinding alone. Blasting shall be used on both asphalt concrete and hydraulic cement concrete pavements to remove all other types of markings. Other methods may be submitted for approval by the Engineer. The Contractor shall ensure that the roadway surface is damaged as little as possible when performing the eradication.

When eradicating pavement markings, the Contractor shall ensure workers are protected in conformance to the requirements of *Occupational Safety and Health Administration's (OSHA)* standards as detailed in 29 CFR 1910 or 1926, whichever is the most stringent at the time. The Contractor shall collect the eradication residue during or immediately after the eradication operation, except dust shall be collected during the entire operation. Eradication

residue from the removal of any pavement markings is considered to be a non-hazardous waste material and shall be disposed of in a properly permitted waste disposal facility in accordance with state and federal laws and regulations. Testing of the eradication residue for the eight Resource Conservation Recovery Act metals will not be required.

When markings are removed for lane shifts or transitions, 100 percent of the marking shall be removed.

Non-reflective removable black construction pavement marking may be used to cover existing markings in lieu of eradication on asphalt concrete surfaces when its use will not be required for more than 120 days and when specified as a pay item. The Contractor shall use this material to cover markings as indicated in the plans or as directed by the Engineer. Non-reflective removable black construction pavement marking shall be applied in accordance with the manufacturer's recommendations.

- (k) **Temporary Pavement Markers:** Temporary pavement markers shall be installed with construction pavement markings, except non-reflective removable markings, in transition (lane drop) or lane shift areas of work zones that will encroach upon the traveled roadway for a period of more than 3 days and in other areas as required by the Engineer.

Temporary pavement markers shall be installed on 20-foot centers in lane shift and transition areas. When temporary pavement markers are required in other areas, they shall be installed on 40-foot centers unless otherwise required by the Engineer. Temporary pavement markers shall be located between and in alignment with broken lines and beside solid line pavement markings. Where double-line pavement markings separating traffic are installed, two-way markers shall be installed beside each line. The Contractor may install two one-way markers in lieu of each two-way marker at no additional cost to the Department.

Temporary pavement markers shall be installed with a hot-applied bitumen adhesive except epoxy may be used on hydraulic cement concrete roadways and non-final surfaces of asphalt concrete roadways. Damage to the pavement by removal of markers shall be repaired in kind by the Contractor at no additional cost to the Department.

Temporary pavement markers found in need of replacement shall be replaced by the Contractor at no additional cost to the Department except those markers damaged by the Department's snow removal operations or other maintenance and construction operations will be paid for at the contract unit price.

- (l) **Detours:** Where temporary structures are necessary, they shall be designed and provided by the Contractor and of sufficient strength, width, and design to accommodate the volume and character of traffic using the highway. Temporary structures crossing waterways shall provide necessary hydraulic openings to accommodate the flow of the waterway. Temporary structure designs shall be submitted to the Engineer for review.

When a detour is no longer required, as determined by the Engineer, it shall be promptly removed, and the materials shall be disposed of as approved or directed by the Engineer. The Contractor shall design and provide temporary drainage facilities of adequate size to carry the normal flow of the existing drainage or waterway.

- (m) **Aggregate Material:** Aggregate material shall be placed at crossovers, private entrances, and mailbox turnouts and where specified by the Engineer.

- (n) **Construction Pavement Message Markings:** Markings shall be installed at locations designated on the plans and as determined by the Engineer and shall consist of messages that comply with the requirements of Section 704. Construction pavement message marking material including maintenance of the markings shall comply with the requirements for construction pavement markings. Retroreflective measurements shall be taken out of the wheel path locations, and each separate entity of a pavement message marking shall be replaced when the average of the three readings for the entity is below 100 millicandelas per square foot per footcandle.
- (o) **Type III Barricades:** Type III barricades shall conform to the requirements of *NCHRP Report 350*, Test Level 3, be at least 4 feet in width, and be selected from those shown on the Department's Approved List. The Contractor shall provide a certification letter stating the brands and models of Type III barricades on the listing that will be used. In lieu of using Type III barricades on that listing, the Contractor may use other brands and/or models provided that prior to their use he submits a copy of the FHWA acceptance letter indicating their compliance with *NCHRP Report 350*, Test Level 3.
- (p) **Truck-mounted Attenuators:** Truck-mounted attenuators shall conform to the requirements of *NCHRP Report 350*, Test Level 3.

Prior to their use, the Contractor shall submit catalog cuts/brochures of the truck-mounted attenuator and a copy of the FHWA's acceptance letter documenting acceptance of the specific truck-mounted attenuator

The truck-mounted attenuator shall be no less than 72 inches wide and no more than 96 inches wide. The color of the truck-mounted attenuators shall be yellow or orange.

The rear panel shall have alternate 6-inch-wide orange and black chevron (inverted V) stripes. Stripes shall be sloped at a 45-degree angle downward in both directions from the upper center of the rear panel. Stripes shall be fabricated from fluorescent orange prismatic lens reflective sheeting conforming to the requirements of Section 247.02(e).

The weight of the support truck shall be as recommended by the manufacturer of the truck-mounted attenuator. The Contractor shall provide a copy of the manufacturer's recommendation to the Engineer and a copy of a weigh ticket for the truck. The weigh ticket shall contain adequate information to associate the ticket with the applicable truck. Additional weight may be added to the support vehicle to achieve the range recommended by the manufacturer of the truck-mounted attenuator provided the total weight is within the Gross Vehicle Weight Recommendation of the support vehicle and is installed such that no movement will occur during impacts.

The support vehicle shall have at least one rotating amber light or high-intensity amber strobe light functioning while in operation in accordance with the *Virginia Work Area Protection Manual (visible for 360 degrees)*. When allowed by the *Virginia Work Area Protection Manual*, an electronic arrow operated in the caution mode may be used in lieu of the rotating or high-intensity amber strobe light.

The transmission of the support vehicle with the truck-mounted attenuator in use shall be in second gear, except for those with an automatic transmission, which shall be in park. The parking brake shall be applied and the front wheels aligned straight ahead when operating in the stationary mode.

Limitations: Support vehicles shall not be used for other purposes while the truck-mounted attenuator is being used. There shall be no additional devices in the bed of the support vehicle except the additional weight as allowed in this Section and traffic control devices such as truck-mounted electronic arrows. There shall be no additional devices, including, but not limited to, signs, lights, and flag holders attached to the truck-mounted attenuator except those that were tested on the truck-mounted attenuator and provided by the manufacturer of the truck-mounted attenuator.

In the event the truck-mounted attenuator is impacted, resulting in damage that would cause the unit to be ineffective, all work requiring the use of the truck-mounted attenuator shall cease until such time that the Contractor can provide an acceptable unit by means of repair or replacement.

Work performed in conjunction with (i), (j), (k), and (n) herein shall be performed in accordance with the requirements of Section 704 except as noted herein.

Replacement and correction of ineffective work zone traffic control devices: These shall be accomplished in accordance with the *American Traffic Safety Service Association's (ATSSA) Quality Standards for Work Zone Traffic Control Devices* with the following additions and exceptions:

1. Requirements herein for replacement and correction of construction pavement markings shall be used in lieu of the requirements in the section entitled "Evaluation Guide Pavement Tape & Raised Pavement Markers."
2. The categories for "Arrow Panel (Flashing Arrow and Double Arrow Mode)" shall be replaced by the following:

Acceptable: No lamps out in stem and arrow head(s), and dimming properly.

Marginal: No more than 1 lamp out in the stem and no lamps out in the head(s), and dimming properly.

Unacceptable: Any lamp out in the head(s) or more than 1 lamp out in the stem, or arrow panel not dimming properly.

3. "Arrow Panel (Caution Mode - Bar or Corners)" shall be replaced by the following:

EVALUATION GUIDE - ARROW PANEL (CAUTION MODE - CORNERS)

Acceptable: No lamps out and dimming properly.

Unacceptable: Any lamp out or arrow panel not dimming properly.

Any operating lamp that is out of alignment will be considered not functioning.

4. The "unacceptable" category for arrow panels shall necessitate immediate corrective action if the device is found in operation on the jobsite.

(q) **Portable Changeable Message Sign (PCMS):**

Units shall be self-contained, including message board, power supply, and trailer. The controller head shall have a back-up system to prevent loss of memory. The trailer and sign frame shall be painted federal yellow or Virginia Highway Orange (DuPont Color #LF74279 AT or color equivalent). The sign panel support shall provide for an acceptable roadway viewing height that shall be not less than 7 feet from bottom of sign to crown of road.

The message board shall provide for 3 lines of legend and shall be formed of characters no less than 18 inches high. Each line shall be composed of at least eight characters and each character module shall at a minimum use a five-wide by seven high pixel matrix. The message shall be composed from keyboard entries. The message shall be legible in any lighting condition. Motorists should be able to read the entire PCMS message twice while traveling at the posted speed.

The sign shall be capable of sequentially displaying at least 3 messages of 3 lines each with appropriate controls for selection of messages and variable off-on time.

The Contractor shall determine from its plan of operations or working schedule the most efficient and effective use of the PCMS units based on its construction sequencing or traffic control operations. PCMS signs shall be periodically checked by the Contractor for compliance with manufacturer's requirements for operation and functions, and shall be ready for immediate use once employed on the project.

During emergency situations the Contractor shall make every effort to deploy units it has assigned to the project. However, if the number of units shown on the plans are already in operation and cannot be reassigned to handle the emergency situation, then the Contractor shall immediately contact the Engineer. The Engineer will then make a determination as to the most expeditious manner in which to deploy units for emergency use, whether by using Department supplied units, directing the Contractor to reassign those units he has committed to the project, or having the Contractor supply additional units as may be necessary. In these circumstances, the cost for such additional units that are authorized by the Engineer shall be in accordance with the requirements of Section 109.05.

If the use of additional units beyond the number of those identified in the plans is required due to reasons attributable to the Contractor or his manner of operations as determined by the Engineer, and no units are available, the Contractor shall furnish such additional unit(s) to the project within two hours of the Engineer's request or the Department will move to provide such units as necessary and deduct the cost from any monies due the Contractor. This action shall in no way relieve the Contractor of the responsibility for controlling, maintaining, and completing the work.

The number of units estimated by the Department to be used for the project will be as shown on the plans. The number of units and hours of use estimated by the Department was based on the suggested Sequencing of Construction shown in the plans and may be different from the Contractor's own construction plan.

512.04—Measurement and Payment

Flagger service will be measured in hours as authorized or approved by the Engineer except when used for the Contractor's convenience, such as for ingress and egress for moving construction equip-

ment or materials. In such cases, payment will not be made for flagger service. Flagger service will be paid for at the contract unit price per hour. This price shall include paddles, safety equipment, and portable traffic control signals.

Pilot vehicles will be measured in hours of actual use, as required by the Engineer, and will be paid for at the contract unit price per hour. This price shall include vehicles, necessary warning devices, drivers, fuel, and maintenance.

Electronic arrows will be measured in hours of actual use, as required by the Engineer, except when used as an option to the use of a rotating amber light or alternating high-intensity amber strobe light. In such cases, payment will not be made for electronic arrows. Electronic arrows will be paid for at the contract unit price per hour. This price shall include arrow panels, fuel, maintenance, and a truck or trailer having flashing amber warning lights.

Warning lights for use on sign panels will be measured in days of actual use for the type specified and will be paid for at the contract unit price per day. This price shall include maintaining, relocating, and removing warning lights. Warning lights installed on traffic barrier service will not be measured for separate payment, but the cost thereof shall be included in the linear foot price bid for traffic barrier service.

Group 1 channelizing devices will not be measured for separate payment. The cost thereof shall be included in the price for other appropriate pay items.

Group 2 channelizing devices, as required by the Engineer, will be measured in days and will be paid for at the contract unit price per day. This price shall include maintaining devices, removing devices when no longer required, and signs. When Group 2 channelizing devices are moved to a new location or are removed and re-installed at the same location, they will be measured for separate payment. However, when the Group 2 channelizing devices are moved from one lane to another by simply moving the devices across the lane edge line without removal from the roadway, no additional payment will be made.

Traffic barrier service will be measured and paid for at the contract unit price per foot per location. This price shall include warning lights, delineators, barrier vertical panels, fixed object attachments, patching restraint holes, maintaining, and removing when no longer required. When fixed object attachments are used on traffic barrier service in locations where existing guardrail is in place, this price shall include restoring existing guardrail to its original condition. When traffic barrier service is moved to a new location as directed or approved by the Engineer, the relocation will be measured for separate payment. Payment for traffic barrier service will not be made until the work behind the barrier is actively pursued.

Traffic barrier service guardrail terminal will be measured and paid for in units of each or linear feet, as applicable, which price shall include furnishing, installing, and removing when no longer needed. When traffic barrier service guardrail terminal is moved to a new location, as directed or approved by the Engineer, the relocation will be measured for separate payment.

Impact attenuator service will be measured in units of each and will be paid for at the contract price per each. Impact attenuators used with barrier openings for equipment access will not be measured for separate payment.

Temporary traffic control signal will be paid for on a lump sum basis. This price shall include, but not be limited to, poles; span wire; conduit; conductor cable; traffic signal heads; backplates; hanger

assemblies; necessary control items; vehicle detection; and, when approved, portable traffic control signal equipment. The price shall also include maintaining, adjusting, and aligning equipment; providing electrical service; utility company costs; and removing equipment when no longer required.

Construction pavement markings will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include marking materials, preparing the surface, adhesive, maintaining, removing removable markings when no longer required, inspections, and testing.

Construction pavement message markings will be measured in units of each and will be paid for at the contract unit price per each. This price shall include marking materials, preparing the surface, adhesive, and maintaining and removing removable markings when no longer required.

Temporary pavement markers will be measured in units of each and will be paid for at the contract unit price per each. This price shall include furnishing and installing pavement markers, surface preparation, adhesive, maintaining and replacing lost or damaged markers, and removing the pavement markers and adhesive when no longer required.

Eradication of existing pavement markings will be measured in linear feet of a 6-inch width or portion thereof. Widths that exceed a 6-inch increment by more than 1/2 inch will be measured as the next 6-inch increment. Eradication of existing pavement markings will be paid for at the contract unit price per linear foot. This price shall include removing pavement line markings and messages and disposal of residue.

Temporary detours will be measured in linear feet along the centerline of the detour or by individual components with the quantities shown on the plans as maintenance of traffic items, in which the components will be measured in accordance with the applicable specifications. This price shall include removing and restoring. When a pay item, temporary detour will be paid for at the contract unit price per linear foot. This price shall include excavating, aggregate materials, drainage items, grading, asphalt, maintaining and removing detour, disposing of surplus and unsuitable material, and restoring property.

Aggregate material will be measured in tons and will be paid for at the contract unit price per ton for the type specified. This price shall include preparing the grade and furnishing, placing, maintaining, and removing material as required.

Type III barricades will be measured in units of each and will be paid for at the contract bid price per each for the width specified. Multiple 4-foot-wide Type III barricades may be used together to obtain the width being specified in the pay item. This price shall include the barricades; retroreflective sheeting; and maintaining, relocating to new locations, and removing the barricades when no longer required.

Construction signs will be measured in units of square feet and will be paid for at the contract price per square foot. This price shall include furnishing, installing, maintaining, covering and uncovering, relocating, and removing temporary sign panels, sign supports, hardware, delineators and flags. Payment based on square footage shall be compensation for the sign(s) for the duration of the project; multiple payments for the same sign used more than once will not be allowed.

Truck-mounted attenuator will be measured in hours of actual use and will be paid for at the contract unit price per hour. This price shall include the truck-mounted attenuator; support vehicle; lights;

electronic arrows if allowed but not required; and maintenance. When electronic arrows are used at the option of the Contractor in lieu of the rotating or high-intensity amber strobe light, the cost of the electronic arrow shall be included in the price bid for truck-mounted attenuators. When electronic arrows are required and not only allowed on the truck-mounted attenuator support vehicles, they will be paid for separately.

Portable traffic control signal will be paid for on a lump sum basis. This price shall include portable traffic control signal equipment; installation; energy source; and maintaining, adjusting, aligning, removing, and relocating equipment.

Portable changeable message sign will be measured and paid for in hours of use, which price shall be full compensation for furnishing or mobilizing the unit(s) to the project, maintenance, operation, and repositioning the unit(s).

Payment will be made under:

Pay Item	Pay Unit
Flagger service	Hour
Pilot vehicle	Hour
Electronic arrow	Hour
Warning light (Type)	Day
Group 2 channelizing device	Day
Traffic barrier service (Type and/or Standard)	Linear foot
Traffic barrier service Guardrail terminal (Standard)	Each or Linear foot
Impact attenuator service (Type)	Each
Temporary signalization	Lump sum
Construction pavement marking (Type and width)	Linear foot
Construction pavement message marking (Type and message)	Each
Eradication of existing pavement marking	Linear foot
Temporary pavement marker ([]-way)	Each
Temporary detour (Standard and type)	Linear foot
Aggregate material (No.)	Ton
Type III barricade (Width)	Each
Construction signs	Square foot
Truck-mounted attenuator	Hour
Temporary traffic control signal	Lump sum
Portable traffic control signal	Lump sum
Portable Changeable Message Sign	Hour

SECTION 513—MOBILIZATION

513.01—Description

This work shall consist of performing preparatory operations, including moving personnel and equipment to the project site; paying bonds and insurance premiums; and establishing the Contractor's of-

ices, buildings, and other facilities necessary to allow work to begin on a substantial phase of the Contract.

513.02—Measurement and Payment

Mobilization will be paid for at the contract lump sum price. This price shall include demobilization.

Payment for mobilization up to the limitations specified hereinafter will be made in two separate installments. The first installment of 50 percent of the contract lump sum price will be made on the first progress estimate following partial mobilization and initiation of construction work. The second installment will be made on the next progress estimate following completion of substantial mobilization, including erection of the Contractor’s offices and buildings. Completion of erection of processing plants, if any, will not be required as a condition for the release of the second installment.

If the original contract lump sum price exceeds the limit stated hereinafter, the excess will be included on the semifinal estimate as follows:

More Than	To and Including	Limit
\$0	\$200,000	10% of total contract amount
200,000	1,000,000	\$20,000 plus 7.5% (of total contract amount minus \$200,000)
1,000,000	More	\$80,000 plus 5% (of total contract amount minus \$1,000,000)

No additional payment will be made for demobilization and remobilization because of shutdowns, suspensions of work, or other mobilization activities.

When not shown as a pay item, the cost of mobilization shall be included in the price bid for other appropriate items.

Payment will be made under:

Pay Item	Pay Unit
Mobilization	Lump sum

SECTION 514 – FIELD OFFICE

514.01—Description

This work shall consist of furnishing, erecting, equipping, maintaining and removing upon completion a field office of the type specified for the exclusive use of Department Engineers and Inspectors at a location on the project approved by the Engineer.

514.02—Procedures

The field office and equipment as required herein shall remain the property of the Contractor. The field office shall be separated from buildings and trailers used by the Contractor and shall be erected and made functional as an initial operation. Failure to have the field office functional when work first begins on the project will result in withholding payment of the Contractor's monthly progress estimate, except that the estimate will not be withheld if the Contractor has shown that the failure is not due to negligence on his part or for reasons beyond his control. The field office shall be operational throughout the duration of the project and shall be removed upon completion and final acceptance of the project. Furnishings and equipment specified shall be in sound and functional condition throughout the duration of the project.

The field office shall be weatherproof, tightly floored and roofed, constructed with an air space above the ceiling for ventilation, supported above the ground and anchored against movement. The width of the field office shall be at least 8 feet, and the floor-to-floor ceiling height shall be at least 7 feet 6 inches. If a trailer is provided for the field office, its width shall be at least 7 feet 6 inches and the floor-to-ceiling height shall be at least 6 feet 6 inches. The inside walls and ceilings shall be constructed of, Masonite, gypsum board, or other similarly suitable materials as permitted by fire and building codes. The exterior walls, ceiling and floor shall be insulated. Field office shall be provided and outfitted as follows according to the type specified.

Type I Field Offices shall have an enclosed floor space of at least 500 square feet with 100 square feet of counter space and 120 square feet of overhead shelving. The field offices shall be equipped with the following:

Quantity	Item
4	Double-pedestal desk, keyed, (approximately 60 inches by 34 inches) at least 2,000 square inches
1	Plan and drafting table (approximately 30 inches by 96 inches) with an adjustable stool
2	Computer tables - 29 inch height, with surface area approximately 48 inches by 30 inches
3	4-Drawer metal fire protection file cabinets, 15-inch drawer width, minimum UL rating of Class 350
2	2-Drawer fire protection file cabinet, 15 inch drawer width, minimum UL rating of Class 350
2	Rolling Plan rack for 24 by 36 inch drawings with 6 plan clamps
2	Bookcase 36 inches by 42 inches with four shelves
1	Dry erase board – wall mounted, minimum 15 square feet, with eraser and markers
1	Small frost free refrigerator
1	Small microwave
2	Printing calculators
6	Office Chairs, 2 with casters
3	Wastebaskets
3	Folding conference tables – minimum 36 inches by 72 inches
4	Folding chairs
1	Pencil sharpener
1	Answering Machine
1	Facsimile machine with optional memory and service contract for preventative maintenance, including replacement print cartridges
1	Copy machine with the following features:

Quantity	Item
	—Capability of copying 8–1/2” x 11”, 8–1/2 x 14” and 11” x 17” sized originals
	—Bin sorter
	—Automatic Feed
	—Automatic paper size selection
	—Size magnification/reduction from 200% to 50% of original image size
	—Service contract with preventive maintenance, including drum replacement and toner supply
1	First Aid kit containing eyes and skin protection for emergencies.
2	Smoke detectors with batteries

Type II Field Offices shall have an enclosed floor space of at least 400 square feet and shall be equipped with the following:

Quantity	Item
1	Double–pedestal desk, keyed (approximately 60 inches by 34 inches) at least 2,000 square inches
1	Plan and drafting table (approximately 30 inches by 96 inches) with an adjustable stool
1	Computer table - 29 inch height, with surface area approximately 48 inches by 30 inches
1	4-Drawer metal fire protection file cabinet, 15 inch drawer width, minimum UL rating of Class 350
2	2-Drawer fire protection file cabinet, 15 inch drawer width, minimum UL rating of Class 350
1	Rolling Plan rack for 24 by 36 inch drawings with 6 plan clamps
1	Bookcase, 36 inches by 42 inches with four shelves
1	Dry erase board – wall mounted, minimum 15 square feet, with eraser and markers
1	Small frost free refrigerator
1	Small microwave
1	Printing calculator
4	Office chairs, 2 with casters
4	Folding chairs
4	Wastebaskets
1	Folding conference table – minimum 36 inches by 72 inches
1	Pencil sharpener
1	Answering Machine
1	Copier machine capable of copying 8 inch by 11 inch and 11 inch by 17 inch sized originals
1	First Aid kit containing eye and skin protection for emergencies.
2	Smoke detectors with batteries

Type III Field Office shall have an enclosed floor space of at least 200 square feet and shall be equipped with the following:

Quantity	Item
1	Double–pedestal desk, keyed (approximately 42 inches by 30 inches) at least 1,250 square inches
1	Plan and drafting table approximately 30 inches by 72 inches with an adjustable stool

Quantity	Item
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1	Computer table - 29 inch height, with surface area approximately 48 inches by 30 inches
1	4-drawer metal fire protection file cabinet, 15 inch drawer width, minimum UL rating of Class 350
2	2-Drawer fire protection file cabinet, 15 inch drawer width, minimum UL rating of Class 350
1	Rolling Plan rack for 24 by 36 inch drawings with 6 plan clamps
1	Dry erase board – wall mounted, minimum 15 square feet, with eraser and markers
1	Small frost free refrigerator
1	Small microwave
1	Printing calculators
3	Office chairs, 2 with casters
4	Folding chairs
2	Wastebaskets
1	Folding conference table – minimum 36 inches by 72 inches
1	Pencil sharpener
1	Answering Machine
1	First Aid kit containing eye and skin protection for emergencies.
1	Smoke detector with batteries

- (a) **Windows and Doors:** The field office shall have at least three windows with removable screens and appropriately sized blinds or shades. Each window shall have an area of at least 540 square inches, capable of being easily opened and secured from the inside. All field office types shall have at least two exterior passage doors. Doors shall be at least 30 inches in width and 78 inches in height. Exterior passage doors shall be equipped with locks and at least two keys per door shall be furnished to the Engineer or Project Inspector.

In addition, each exterior door shall be equipped with a steel security bar that is installed horizontally and fabricated to lock with a 3/8" diameter padlock shank. The Department will furnish the padlocks for the security bars.

- (b) **Steps:** Steps shall conform to the requirements of the *State Building Code* and shall be maintained free from obstruction.
- (c) **Storage Facility for Nuclear Gage(s):** The field office shall be furnished with an outside storage facility for the Department's nuclear gage(s), which shall not be located within 10 feet of any structure. This facility shall be provided with electrical power and shall be equipped for an interior switched light and one single-phase, 120V, 15 amps, grounded, weatherproof, duplex receptacle for recharging the nuclear gage(s). The storage facility for the nuclear gage(s) shall be weatherproof, tightly floored and roofed, having a tamper resistant key operated lock with two keys furnished to the Engineer or Project Inspector.
- (d) **Storage Facility for Test Equipment:** The field office shall be provided with a storage facility, separate from the office for storage of test equipment, other than the nuclear gage. The storage facility shall have a minimum floor space of 64 square feet and include four shelves at least 11 inches deep mounted along the length of one wall. The storage facility for test equipment shall be weatherproof, tightly floored and roofed, having a tamper resistant key operated lock with two keys furnished to the Engineer or Project Inspector.

- (e) **Lighting, Heating, and Air Conditioning:** The field office shall have satisfactory functional lighting, electrical outlets, heating equipment, an exhaust fan, and air conditioner connected to an operational power source. At least one of the light fixtures shall be a fluorescent light situated over the plan and drafting table. There shall also be at least one 100 watt exterior light fixture at each exterior doorway. Electrical power and fuel for heating equipment shall be furnished by the Contractor.
- (f) **Fire Extinguishers:** The Contractor shall furnish and maintain one fire extinguisher for each required exterior passage door. Fire extinguisher(s) may be chemical or dry powder, UL Classification 10B:C (minimum), suitable for Type A:B:C fires and shall be mounted and maintained in accordance with OSHA Safety and Health Standards.
- (g) **Toilets** – Toilets shall conform to the requirements of the state and local boards of health or other bodies or courts having jurisdiction in the area. Toilet facilities may be either inside the Field Office or portable toilet facilities.

If the Contractor provides toilet facilities inside the Field Office, the toilet facilities shall have a continuous supply of water at a flow rate of not less than five gallons per minute. The toilet facilities shall be connected to either a sewer line or a permitted sewage holding tank with sewage pumping at a frequency that prevents overflow and back ups. The toilet facilities shall have a positive functional lock on the inside of the doors.

If the Contractor provides portable toilet facilities, then there shall be separate facilities for both male and female personnel with appropriate signs for “Men’s Rest Room” and “Women’s Rest Room” having lettering at least 2 inches in height. Both men’s and women’s portable toilet facilities shall have an adequate positive locking system provided on the inside of the doors. The facility labeled “Women’s Rest Room” shall also have a positive, uniquely-keyed, exterior locking device; and the Contractor shall provide two keys to the Engineer or Project Inspector.

The Contractor shall provide washing facilities in accordance with VOSH regulations.

- (h) **Drinking Water:** The Contractor may provide either potable water inside the Field Office or bottled drinking water service that includes a dispenser capable of providing both hot and cold water, and disposable cups. The Contractor shall cause the bottled drinking water service to replenish both bottled water and disposable cups no less frequently than twice per month.
- (i) **Utilities:** Except for telephone services, the Contractor shall make arrangements for necessary utility connections, maintain utilities, pay utilities service fees and bills, and make arrangements for final disconnection of utilities. The Contractor shall also furnish two touch tone telephones in each field office and permit the work necessary to install them.
- (j) **Miscellaneous Items:** The field office shall also include the following:
 1. A certification that the office is free of asbestos and other hazardous material.
 2. A broom, dust pan, mop, mop bucket, general cleaning supplies, and trash bags.
 3. An all weather parking area for either twelve vehicles (for a Type I office) or six vehicles (for either a Type II or a Type II office), and all weather graveled access to the

public roadway. The Contractor shall maintain the parking area and graveled access such that it is passable with a compact sedan without causing vehicular damage. The parking lot shall be sufficiently lighted to illuminate all areas of the lot.

4. Security measures for the Field Office during other than normal working hours shall be equivalent to that used by the Contractor for his job site and office facilities.

514.03—Measurement and Payment

Compensation for use of the field office will be based on the time it is used, expressed in calendar months. This price shall include furnishing, erecting, maintaining, and removing the field office when no longer required, and providing the facilities, furnishings, equipment, utilities and services as described herein. Payment for periods less than one month shall be based on the pro-rata days during the month in which the field office is in use by the Engineer, except that payment will not be made for any time in excess of the time limit established in the Contract as extended in accordance with the requirements of Section 108.04.

Installation and service fees for the telephone(s) will be paid for by the Department.

Payment will be made under:

Pay Item	Pay Unit
Field Office (Type)	Month

SECTION 515—PLANING PAVEMENT

515.01—Description

This work shall consist of planing rigid or flexible pavement to the designated depth in preparation for pavement repair or pavement overlay.

515.02—Procedures

Planing shall be performed with a pavement-planing machine of a type that has operated successfully on work comparable to that specified in the Contract.

Equipment and vehicles in use under traffic shall operate flashing or rotating amber lights. In addition, trail vehicles shall be equipped with electronic flashing or sequential amber arrows.

Irregularities and high spots shall be eliminated. The pavement surface shall be planed to the designated grade or gradient of approximately 1/4 inch per foot or as directed by the Engineer. Superelevated curves shall be planed as directed by the Engineer. Where the pavement is to be resurfaced, a 1-inch shoulder shall be cut along the gutter line to eliminate the necessity of feathering the edge of the new surface. Payment for providing the 1-inch shoulder shall be based on the total square yards of re-

moved material regardless of the variable depth of the pass. Pavement cuttings shall be disposed of in accordance with the requirements of Section 106.04.

The planed surface shall be free from gouges, grooves, ridges, soot, oil film, and other imperfections and shall have a mosaic appearance suitable as a riding surface.

- (a) **Hot Planing Methods:** Hot planing equipment shall be a self-propelled machine capable of heating, planing, and removing flexible pavement to the required depth, profile, and cross section. The machine shall be capable of cutting to a depth of at least 1/2 inch per pass and shall have an integral loader to pick up cuttings from the roadway and discharge them into a truck in a single operation. Planing machine burners shall use a heating fuel that will not cause aggregates or asphalt to be coated with soot or oil.
- (b) **Milling and Cold Planing Methods:** Milling and cold planing equipment shall be capable of cutting to a depth of 2 inches in flexible pavement and 1/2 inch in rigid pavement while leaving a uniformly cut roadway surface capable of handling traffic prior to overlay placement. The ground speeds of the machine and the cutting equipment shall be independent. The machine shall have a self-contained water system for the control of dust and fine particles. The width of the machine shall allow controlled traffic.

515.03—Measurement and Payment

Where pavement is to be planed to a uniform depth, planning will be measured in square yards of removed pavement surface area per inch of depth and will be paid for at the contract unit price per square yard per inch. Where planning will be variable depth, planning will be measured in square yards of removed pavement surface area per pass per inch of depth measured at the maximum depth of removed pavement. This price shall include vehicles, safety equipment, warning devices, and removing and disposing of existing pavement.

Payment will be made under:

Pay Item	Pay Unit
Flexible pavement planing	Square yard
Rigid pavement planing	Square yard

SECTION 516—DEMOLITION OF BUILDINGS AND CLEARING PARCELS

516.01—Description

This work shall include disconnecting utilities, closing wells, demolishing building(s), removing materials from the right of way, and removing improvements and material unsuitable for use in roadway embankments from vacant parcels and other areas within the right of way.

516.02—Procedures

- (a) **Utilities:** The Contractor shall make necessary arrangements and perform necessary work, in accordance with local ordinances, involved with disconnecting or interrupting public utilities or services. These shall include, but not be limited to, gas, water, sewer, electricity, and telephone.
- (b) **Closing Wells:** The Contractor shall close all wells prior to any demolition and clearing parcels in accordance with State Board of Health Private Well Regulations, State Water Control Board, and local jurisdictions.
- (c) **Refrigerant-Containing Appliances:** The Contractor shall disconnect all chemical refrigerant-containing equipment including air conditioners and heat pumps in accordance with state and federal laws and regulations; any disconnections shall be made by certified individuals.
- (d) **Demolition:** The Contractor will be notified in writing when buildings are ready for demolition. Demolition shall include removing and disposing of materials from buildings and appurtenances down to the ground lines or below the ground lines in the case of basements or similar existing below-ground structure. Any structures that contain non-regulated asbestos-containing materials shall be demolished in accordance with the Special Provision for Demolition of Structures Containing Non-Friable Asbestos-Containing Materials.

The Contractor may use buildings designated for demolition for project-related office space or storage or as a field office for Department personnel only after approval is obtained from the Engineer in writing prior to occupancy. The Contractor shall remove all regulated asbestos-containing materials (RACM) in accordance with the Special Provision for Asbestos Removal for Road Construction Demolition Projects prior to occupancy.

The Contractor shall assume all personal and property liability associated with the use of or salvaging of materials from such buildings and shall protect and save the state harmless from any and all damages and claims associated with such buildings. Salvage operations shall not be performed in advance of the Department's asbestos inspection, and if asbestos-containing materials are identified, prior to asbestos abatement activities. The Contractor is advised that the Department's asbestos inspection procedures are intended to support whole structure demolition and, as such, may not be sufficient to support worker protection for salvage operations. Any additional testing, abatement, notification, and/or worker protection activities required to salvage materials shall be the sole obligation of the Contractor at his expense.

Buildings, materials resulting from their removal, and improvements on the property shall become the property of the Contractor at the time of their removal and shall be disposed of outside and away from the parcel site. Nothing herein shall be construed as giving the Contractor any rights in and to the buildings in the Contract except for their demolition or for the purposes permitted herein. The Contractor shall have no right to sell or lease the buildings. The Department does not warrant or guarantee the existence or continued existence of any materials that are a part of the demolition item(s), and the Department will not be responsible in any way thereof to the Contractor.

- (e) **Clearing Parcels:** Parcels shall not be cleared until buildings have been demolished or removed.

Clearing parcels shall include disposing of materials from noncombustible foundations down to and including floor slabs, basement slabs, and any improvement designated for removal but not listed as a pay item. Combustible debris and rubble, including fences, posts, or pillars, shall also be removed from the right of way or from within the limits of easements obtained for removing buildings that may be partially outside the right of way.

The Contractor shall limit the cutting or removing of trees and shrubs to those necessary for completion of the work as approved by the Engineer. Trees or shrubs that are cut shall be removed from the right of way. The Contractor shall not enter or encroach on any parcel that is not included in the Contract.

Materials contained in cisterns, septic tanks, and other openings, including basements, shall be removed and properly disposed of in accordance with the requirements of Section 107.01. Underground tanks shall be closed and removed; cisterns, septic tanks, and other openings, including basements, shall be demolished; and the area shall be backfilled with materials suitable for use in roadway embankment in accordance with the requirements of Section 303.

516.03—Measurement and Payment

Demolition of buildings will be paid for at the contract lump sum price for the parcel and structure specified. This price shall include coordinating and performing utility work, disposing of materials, and cleaning up. The Contractor shall also take into consideration the salvage value of any material removed and shall include the same in the lump sum price.

Clearing parcels will be paid for at the contract lump sum price for the specified parcel. This price shall include disposing of materials, backfilling, and cleaning up. The limits of payment shall be from the construction limits to the right-of-way or easement line.

Closing wells will be measured and paid for on an each basis, which price shall include chlorination, cement grout or bentonite grout, or other material as applicable; backfilling; and filing of abandonment documents with the Virginia Department of Health. The Contractor shall execute and file abandonment documents in accordance with the requirements of Section 107.01.

Payment will be made under:

Pay Item	Pay Unit
Demolition of building (Parcel no.) (D no.)	Lump sum
Clearing parcel (Parcel no.)	Lump sum
Closing well	Each

SECTION 517—CONTRACTOR CONSTRUCTION SURVEYING

517.01—Description

This work shall consist of the Contractor providing all surveying and stakeout as detailed herein for the successful prosecution of work as indicated on the plans and as directed by the Engineer. Stakeout work shall be in accordance with the Department's Survey Manual and this specification

517.02—General Requirements

The Contractor shall ensure the following surveying work shall be performed by or under the direct responsibility, control and personal supervision of a surveyor who is licensed in Virginia as a Land Surveyor and is experienced in highway construction stakeout work including the following:

- (a) horizontal and vertical control for bridges,
- (b) horizontal and vertical control for box culverts and single and multiple line pipe culverts as specified herein,
- (c) horizontal and vertical control for additional centerlines or baselines for roadways, ramps, loops and connections and
- (d) fine grade or other grade stakes as necessary for construction.

All other surveying work shall be performed by or under the direct supervision and control of the Contractor who is experienced in highway construction stakeout.

The Contractor shall preserve Department furnished centerline or baseline control, references and location benchmarks. The Contractor shall provide all construction benchmarks and reference stakes he develops as detailed herein. All alignment established by the Contractor shall be referenced, with a copy of the references furnished to the Engineer.

The Contractor shall provide the Engineer with a record copy of certified plats, survey drawings, field notes and computations prior to the use of said stakeout information for construction. Survey record drawings shall be prepared and certified in accordance with the requirements of this specification and the sample figure drawings as shown in the Department's Survey Manual. Electronic data files may be submitted along with paper sketches and drawings, subject to the prior approval of the Engineer. All electronic copies submitted shall be in a format fully compatible with the Department's existing computer hardware and software.

517.03—Contractor Responsibility for Examination of Data

It shall be the responsibility of the Contractor to examine all surveying work provided by the Department for accuracy. Should a disagreement involving the accuracy of stakeout or survey work arise during construction, the Contractor shall within 24 hours provide written notice to the Engineer, precisely describing and documenting the discrepancy. The Engineer will determine the validity of the Contractor's assertion in the notice, respond to the Contractor within 3 working days of receipt of the Contractor's notice and provide direction on how to proceed. The Engineer will give consideration to

an extension of time in accordance with the requirements of Section 108.04 of the Specifications or provide additional compensation as deemed appropriate after documentation and evidence to the Engineer's satisfaction if the following occurs:

- (a) There are delays to the project as a result of inaccurate stakeout information provided by the Department where such delays adversely impact the critical path of the work or,
- (b) Where extra expense is encountered by the Contractor to correct elements of defective survey work by the Department, and
- (c) Where written notice is provided by the Contractor within the timeframe specified. Failure to furnish written notice of such a discrepancy within the timeframe specified will invalidate any later claim for time impact or costs by the Contractor unless specifically waived by the Engineer.

517.04—Construction (C) projects

The following specific requirements shall apply:

- (a) **Digital Terrain Model (DTM) and Construction Cross-sections:** Original location Digital Terrain Model (DTM) will be provided by the Department and will serve as a basis of payment for earthwork. The Contractor shall be responsible for taking construction DTMs or cross-sections of areas that, in their determination, do not agree with the Department furnished original location DTMs. The Contractor shall submit the disputed DTM information to the Engineer for verification prior to any excavation by the Contractor in these alleged areas of change. The DTM information furnished by the Department and submitted by the Contractor shall be compatible to the Department's current DTM format.
- (b) **Borrow Pits:** All borrow pit DTMs or cross-sections, originals and finals, will be secured by the Engineer through the Department Survey party. The Contractor is encouraged to also secure DTMs or cross-sections of borrow areas. A claim of discrepancy in borrow volume will not be considered by the Engineer unless survey data was obtained and submitted by the Contractor to substantiate their claim.
- (c) **Temporary Benchmarks:** The Contractor shall provide and protect temporary construction benchmarks within the construction limits. Temporary construction benchmarks shall be located not farther than 500 feet apart for the total length of the project or as indicated on the plans. Temporary construction benchmarks that are disturbed by the Contractor's activities during construction operations shall be reestablished by the Contractor at no additional cost to the Department.
- (d) **Horizontal and vertical control for bridges:** The Contractor shall stake all bridges. These stakeouts shall require certified plats. Certified plats, field notes, coordinates and computations shall be furnished by the Contractor to the Engineer in accordance with the requirements of Sample Figures 2 and 3 as shown in the Department's Survey Manual prior to the Contractor beginning work on these structures.
- (e) **Horizontal and vertical control for all box culverts, all pipe culvert installations (including single and multiple line installations) with a total hydraulic opening equivalent to 12.6 square feet and larger, and for all closed systems such as storm sewers, and**

sanitary sewers regardless of size: These stakeouts are deemed critical and require certified plats. The Contractor's surveyor shall stake all such installations. Certified Plats for these stakeouts shall be furnished in accordance with the requirements of Sample Figure 1 as shown in the Department's Survey Manual and shall be submitted to the Engineer prior to the Contractor beginning installation work on these culvert structures. The notes, coordinates, or computations used to support the platted information shall be provided to the Engineer with the certified plat. For the purposes of identifying those pipe culvert installations please refer to the areas (hydraulic openings) shown in the PB-1 Standards for the respective sizes of pipes specified on the plans. Where multiple lines of pipes are shown, the areas of the pipe sizes shall apply to the total areas of the number of lines specified in the plans. For box culverts refer to the sizes shown in the BC-1 Standards to determine areas of total hydraulic opening.

- (f) **Horizontal and vertical control for pipe culvert installations (including single and multiple line installations) having a total hydraulic openings equivalent to 3.1 square feet and up to 12.5 square feet:** The Contractor shall be responsible for staking horizontal and vertical controls for pipe culvert installations having a total hydraulic opening equivalent to 3.1 square feet and up to 12.5 square feet. These stakeouts require sketches, but not certified plats and shall be furnished to the Engineer prior to the Contractor beginning work on these culvert structures. For the purposes of identifying those pipe culvert installations please refer to the areas (hydraulic openings) shown in the PB-1 Standards for the respective sizes of pipes specified on the plans. Where multiple lines of pipes are shown, the areas of the pipe sizes shall apply to the total areas of the number of lines specified in the plans. For box culverts refer to the sizes shown in the BC-1 Standards to determine areas of total hydraulic opening.
- (g) **Horizontal and vertical control for additional centerlines or baselines for roadways, ramps, loops and connections:** The Contractor shall provide horizontal and vertical controls for additional centerlines or baselines for roadways, ramps, loops and connections.
- (h) **Grading and paving construction:** The Contractor shall provide fine grade or other grade stakes required for the construction of the project as the work progresses except as otherwise stated herein.

Fine grade stakes shall be set on all projects on which the plans show a definite grade line. Fine grade hubs shall be set on at least one side with distances and grades referenced to the finished centerline grade. Typically, on curves, the Contractor shall provide the distances and elevations to each edge of pavement and centerline through the transitions and the distances and elevations to the edge of pavement only (straight-line super) through full super portions of the curve.

On projects where grading and paving is performed under the same contract, only one set of fine grade stakes will be required by the Engineer. Fine grade stakes may be used for fine grade and paving grade.

On Secondary Road projects, fine grade stakes shall be provided by the Contractor only on those projects having curb and gutter or as directed by the Engineer.

Special design ditches shall be staked with an offset and cut to the centerline of the ditch. Radius points for pavement flares at connections shall be staked by the Contractor.

Generally, slope stakes shall be set by the Contractor as an initial part of the construction operations on the project.

- (i) **Right of way and boundary stakeout affecting property ownership:** The right of way stakes will be placed at a minimum of 100-foot intervals on each side of the roadway or as directed by the Engineer and the stakes will be marked with both the station and offset back to centerline. All final boundary stakeout will be performed by the Department survey party.
- (j) **Locating and setting right-of-way monuments:** All location and final right of way monumentation will be performed by the Department in accordance Section 105.13.

517.05—Minimum Plan (M) projects

The following specific requirements shall apply:

- (a) **Digital Terrain Model (DTM) and construction cross-sections:** “M” projects are based on plan quantities; therefore DTM and construction cross-sections are not required.

Should the Engineer determine at any time that an actual measurement is warranted, the Department will make the necessary measurement in the field.
- (b) **Borrow Pits:** All borrow pit DTM’s, originals and finals, will be secured by the Department. The Contractor is encouraged to also secure DTMs or cross-sections of borrow areas. A claim of discrepancy in borrow volume will not be considered by the Engineer unless survey data was obtained and submitted by the Contractor to substantiate the claim.
- (c) **Horizontal and vertical control for bridges:** These stakeouts require certified plats. Certified plats, field notes, coordinates and computations shall be furnished to the Engineer by the Contractor in accordance with the requirements of Sample Figures 2 and 3 as shown in the Department’s Survey Manual prior to the Contractor beginning work on these structures.
- (d) **Horizontal and vertical controls for all box culverts, all pipe culvert installations (including single and multiple line installations) with a total hydraulic opening equivalent to 12.6 square feet and larger, and for all closed systems such as storm sewers, and sanitary sewers regardless of size:** These stakeouts are deemed critical and require certified plats. Exceptions may be granted by the Engineer for simple closed systems by requiring stake out sketches. The Contractor shall stake all such installations. Certified Plats for these stakeouts shall be in accordance with the requirements of Sample Figure 1 as shown in the Department’s Survey Manual and shall be submitted to the Engineer prior to the Contractor beginning work on these culvert structures. The notes, coordinates, or computations used to support the platted information shall be provided by the Contractor to the Engineer with the certified plat.
- (e) **Horizontal and vertical control for pipe culvert installations (including single and multiple line installations) having a total hydraulic openings equivalent to 3.1 square feet and up to 12.5 square feet:** The Contractor shall be responsible for staking horizontal and vertical controls for pipe culvert installations having a total hydraulic opening equivalent to 3.1 square feet and up to 12.5 square feet. These stakeouts require sketches, but not certified

plats and shall be furnished to the Engineer prior to the Contractor beginning work on these culvert structures. For the purposes of identifying those pipe culvert installations please refer to the areas (hydraulic openings) shown in the PB-1 Standards for the respective sizes of pipes specified on the plans. Where multiple lines of pipes are shown, the areas of the pipe sizes will apply to the total areas of the number of lines specified in the plans. For box culverts refer to the sizes shown in the BC-1 Standards to determine areas of total hydraulic opening.

- (f) **Temporary Benchmarks:** The Contractor shall provide and protect temporary construction benchmarks within the construction limits. Temporary construction benchmarks shall be located not farther than 500 feet apart for the total length of the project or as indicated on the plans. Temporary construction benchmarks that are disturbed by the Contractor's activities during construction operations shall be reestablished by the Contractor at no additional cost to the Department.
- (g) **Grading and paving construction:** The Contractor shall provide fine grade or other grade stakes required for the construction of all projects except as stated herein as the work progresses. Slope stakes are not required on "M" projects.

Fine grade stakes shall be set on all projects on which the plans show a definite grade line. Fine grade hubs shall be set on at least one side with distances and grades referenced to the finished centerline grade. Typically, on curves, the Contractor shall provide the distances and elevations to each edge of pavement and centerline through the transitions and the distances and elevations to the edge of pavement only (straight-line super) through full super portions of the curve.

On projects where grading and paving is performed under the same contract, only one set of fine grade stakes will be required by the Engineer. Fine grade stakes may be used for fine grade and paving grade.

On Secondary Road projects, fine grade stakes shall be provided by the Contractor only on those projects having curb and gutter or as directed by the Engineer.

Special design ditches shall be staked with an offset and cut to the centerline of the ditch. Radius points for pavement flares at connections shall be staked by the Contractor.

- (h) **Right of way and boundary stakeout affecting property ownership:** The right of way stakes will be placed at a minimum of 100-foot intervals on each side of the roadway or as directed by the Engineer and the stakes will be marked with both the station and offset back to centerline. All final boundary stakeout will be performed by the Department survey party.
- (i) **Setting right-of-way monuments:** Final right of way monumentation will be performed by the Department in accordance Section 105.13.

517.06—Measurement and payment

Construction surveying will be paid for at the contract lump sum price for the type of project specified, which price shall be full compensation for performing the work prescribed herein, and for all materials, labor, tools, equipment and incidentals necessary to complete the work.

Payment for construction surveying will be made upon written request by the Contractor. Such request shall be submitted to the Engineer no earlier than five days, and no later than two days prior to the progress estimate date. Payment may be made in increments selected by the Contractor. However, payments will not exceed 60 percent of the contract unit price bid until the Contractor has provided the Engineer with surveying field notes, layouts, computations, certified plats, sketches and drawings in the format approved by the Engineer.

Payment will be made under:

Pay Item	Pay Unit
Construction surveying (Construction)	Lump sum
Construction surveying (Minimum Plan)	Lump sum

SECTION 518—TRAINEES ON CONSTRUCTION PROJECTS

518.01—Description

This work shall consist of providing the training specified herein as part of the Contractor's EEO Affirmative Action Program. This specification implements 23 CFR, Part 230, Subpart A, Appendix B.

518.02—Procedures

The Contractor shall provide each trainee with a copy of the specific program and upon completion of the training program a certificate showing the type and duration of training satisfactorily completed. The Contractor shall maintain records and furnish periodic reports documenting compliance with the requirements herein.

- (a) **Number of Trainees:** The number of trainees for each contract shall be as specified. The number of trainees is determined by the District Civil Rights Manager (DCRM). If the Contractor sublets a portion of the contract, the Contractor shall determine how many trainees are to be trained by the subcontractor. The Contractor shall retain the primary responsibility for conforming to the training requirements imposed by this specification. The Contractor shall ensure that these training requirements are made applicable to the subcontract. Where feasible, 25 percent of apprentices or trainees in each occupation shall be in their first year of apprenticeship or training.
- (b) **Distribution of Trainees:** The number of trainees shall be distributed among the work classifications on the basis of the Contractor's needs and the availability of journeymen in the various classifications within a reasonable area of recruitment. The Contractor will be credited for each trainee employed by him under the Contract who is currently enrolled or becomes enrolled in an approved program.

The enrollment of minorities, women, and other disadvantaged persons is approved and monitored by the DCRM. Trainees will be enrolled and approved by the DCRM on Form C-65 prior to the start of training.

- (c) **Minorities and Women:** Training and upgrading of minorities and women toward journeyman status are primary objectives. The Contractor shall make every effort to enroll minority and women trainees by conducting systematic and direct recruitment through public and private sources likely to yield minority and women trainees to the extent such persons are available within a reasonable area of recruitment. The Contractor shall demonstrate the steps taken in pursuance thereof prior to a determination as to whether or not he is in compliance with the requirements herein. This training commitment shall not be used to discriminate against any applicant for training, whether a member of a minority group or not.
- (d) **Use of Journeymen:** No employee shall be employed as a trainee in any classification in which the person has successfully completed a training course leading to journeyman status or has been employed as a journeyman. The Contractor shall satisfy this requirement by including appropriate questions on the employee application or by other suitable means. The Contractor's records shall document the findings in each case.
- (e) **Length and Type of Training:** The minimum length and type of training for each classification will be established in the training program selected by the Contractor and approved by the DCRM. The DCRM will approve a program if it is reasonably calculated to meet the EEO obligations of the Contractor and qualify the average trainee for journeyman status in the indicated classification by the end of the training period. Apprenticeship programs registered with the U.S. Department of Labor, Bureau of Apprenticeship and Training, or with a state apprenticeship program (Virginia Department of Labor & Industry) recognized by the U.S. Department of Labor, Bureau of Apprenticeship and Training, will also be considered acceptable in meeting the trainee contract goal provided they are being administered in a manner consistent with the EEO obligations of the contract. Approval of a training program shall be obtained from the DCRM prior to the commencement of work in the classification covered by the program.

Training shall be provided in the construction trade classifications indicated in the *On the Job Training (OJT) Manual for Standard Pre-Approved Job Classifications*. The Contractor shall provide all training on state or federally funded projects of the Department.

- (f) **Commencement of Training:** It is normally expected that a trainee will begin training on the project as soon as is feasible after the start of the work that requires the skill involved and will remain on the project as long as training opportunities exist in the work classification or until the trainee has completed the training program. It is not required that all trainees be on board for the entire duration of the contract. The number trained will be determined on the basis of the total number enrolled under the contract for the entire contract period.
- (g) **Payment to Trainees:** Trainees shall be paid at least 60 percent of the appropriate prevailing minimum journeyman's rate for the first half of the training period, 75 percent for the third quarter of the training period, and 90 percent of the last quarter of the training period unless apprentices in an approved existing program are enrolled as trainees on the project. In such cases, the appropriate rates approved by the DCRM in connection with the existing program shall apply to all trainees being trained for the same classification who are covered by these requirements.
- (h) **Failure to Provide Required Training:** The Contractor's failure to provide the required training damages the effectiveness and integrity of this Affirmative Action Program and circumvents the Department's federal mandate to bring women and minorities into the con-

struction industry. Therefore, if the Contractor has failed by the end of the project to meet the required trainee contract goal, written good faith documentation shall be submitted indicating the reasons the trainee goal was not attained. This documentation shall be submitted to the DCRM, and should it be determined insufficient, the lack of commitment to this Affirmative Action Program will be relayed to the Engineer for inclusion in the Contractor's Performance Report for the project.

Efforts taken by a Contractor that results in the OJT contract goal being exceeded will be recognized for their support of the Department's commitment to assuring skill improvement opportunities for minorities and women in highway construction. To exceed an OJT goal is to enroll and graduate more trainees than the number specified in the contract.

518.03—Measurement and Payment

Except as otherwise noted herein, the Contractor will be paid \$3.00 per hour for each employee who is trained in accordance with the approved training program. The DCRM can request approval by the Engineer that a Contractor be paid for training persons in excess of the trainee contract goal specified or for trainees enrolled on a contract without a trainee goal. This payment will be made even though the Contractor received additional training program funds from other sources provided such other sources do not specifically prohibit the Contractor from receiving other payments. The Department will pay the Contractor stipend \$3.00 per training hour for training occurring on state or federally funded projects of the Department.

The Contractor will be credited for each apprentice/trainee employed on the project and reimbursed on the basis of hours worked listed on certified payrolls and the weekly submittal of trainee Form C-67. This form will serve as a record of trainee hours completed.

If, in the judgment of the Contractor, Engineer, and DCRM, a trainee becomes proficient enough to qualify as a journeyman before the end of the prescribed training program and the Contractor so employs the trainee, full credit will be given toward the attainment of the trainee goal; however, the Contractor will be paid only for the actual trainee hours completed. The Department will pay the Contractor for only those training hours completed if the trainee does not complete training due to lay-off, termination, or resignation.

No payment will be made to the Contractor should the required training not be provided or the trainee is not hired as a journeyman and there is evidence of a lack of good faith on the part of the Contractor in complying with the requirements specified herein.

SECTION 519—SOUND BARRIER WALLS

519.01—Description

This work shall consist of furnishing and constructing sound barrier walls in accordance with these specifications and approved working drawings and within the specified tolerances for the lines, grades, and details shown on the plans or as established by the Engineer.

(a) Acoustic Performance standards:

1. Sound barrier walls shall provide a transmission loss of at least 23 dB(A) when tested in accordance with the requirements of ASTM E90 using the typical truck noise spectrum and shall have vibration-free joints and fittings.
2. Absorptive sound barrier walls shall be designed so that the absorptive portion on the highway side has a minimum noise reduction coefficient of 0.70 when measured in accordance with the requirements of ASTM C423.
3. Sound barrier walls shall be designed to minimize or eliminate gaps or openings to prevent transmission of sound through the barrier.

(b) **Design Standards:**

1. Structural design loadings for sound barrier walls shall be based on a design life of not less than 50 years. They shall be designed in accordance with the requirements of the current AASHTO Guide Specification for Structural Design of Sound Barriers except as modified herein. References in the AASHTO sound barrier specification to “an industry recognized specification” shall not apply. All concrete, steel, and aluminum members shall be proportioned with reference to the service load design methods (allowable or working stress design) of the current AASHTO Standard Specifications for Highway Bridges. Fatigue and traffic impact shall be considered in the design of these structures. Sound barrier walls subject to lateral earth pressure shall have those portions so loaded, designed in accordance with the aforementioned AASHTO specifications. In all cases, settlement shall also be considered.
2. Unless specified otherwise, this paragraph governs the selection of wind pressure coefficients in Virginia. Any sound barrier wall to be constructed within one half mile of the shore of the Chesapeake Bay or the Atlantic Ocean shall be designed for exposure category D. All other ground-mounted sound barrier walls shall be designed for exposure category B2, and all other structure-mounted sound barrier walls shall be designed for exposure category C. The wind pressure to be applied to the full height of the wall shall be based on the height to the centroid of the loaded area. For structure-mounted walls, this height shall be measured from the surface of the feature over which the bridge or structure crosses (e.g. mean sea level of the Chesapeake Bay, normal water level at stream crossings, roadway surface on the low shoulder at highway intersections) or in the case of sound barrier walls mounted on retaining walls, measured from the prevailing ground elevation in the vicinity.
3. Unless specified otherwise, this paragraph governs the selection of wind speeds for design purposes (50-year mean recurrence interval) in Virginia. Sound barrier walls in Hampton Roads District shall be designed for a wind speed of not less than 100 mph. Walls in Fredericksburg, Northern Virginia and Richmond Districts shall be designed for a wind speed of not less than 90 mph. Walls in Bristol, Culpeper, Lynchburg, Salem and Staunton Districts shall be designed for a wind speed of not less than 80 mph. Any continuous wall crossing district boundaries may use the lower of the two adjacent wind speeds.
4. The vertical posts shall be proportioned to have a maximum deflection of no more than $h/240$ due to wind load, where “h” is the cantilever height of the post from the top of foundation to the top of the sound barrier wall. The unbraced length of the post for design shall not be less than “h” unless both flanges are sufficiently braced to allow a re-

duction of the unbraced length of the section. Post design shall account for all holes needed for connections. Wall panels and other supporting members shall be proportioned to have a maximum deflection of no more than $l/240$ due to wind load, where “ l ” is the length of the panel or member.

5. Structure-mounted sound barrier panels shall not weigh more than 7.5 psf and the structure-mounted sound barrier system shall not weigh more than 15 psf. Posts for structure-mounted sound barrier wall panels shall not be spaced more than 8 feet on center. Posts shall be mounted on the outside of parapets only. Posts for ground-mounted sound barrier panels shall not be spaced more than 24 feet on center. The Contractor and wall manufacturer shall be responsible for the anchorage of the sound barrier wall to the structure to include the location of anchor rods, pattern or layout of rods, size, length of embedment, base plate for attachment, posts, etc. Slip forming of the elements of structures that are designed to receive sound barrier walls will not be permitted.
6. Anchor rod performance shall be evaluated against the net area of the anchor rod after reduction to account for threads. Anchor rods shall be checked against the effect of combined stresses in accordance with the following formula (found in the 2001 AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaires, and Traffic Signals):

$$\left(\frac{f_v}{F_v}\right)^2 + \left(\frac{f_t}{F_t}\right)^2 \leq 1.0$$

Where:

F_t is the allowable normal stress on the rod, $0.5 \times F_y$

f_t is the predicted normal stress on the rod due to direct compression or tension and bending:

$f_t = f_a + f_b$ where:

f_a is the predicted stress on the rod due to direct compression or tension

f_b is the predicted stress on the rod due to bending about the rod's neutral axis

f_b shall be included in the computation of f_t whenever the clearance between the bottom of the leveling nuts and the top of the concrete foundation is greater than or equal to the diameter of the rod

F_v is the allowable stress on the rod due to direct shear, $0.3 \times F_y$

f_v is the predicted stress on the rod due to direct shear

Note: All stresses are based on the applied load acting on the net area after consideration for the reduction due to the presence of the threads.

e.g. NetArea: = $0.7854(D - (0.9743/n))^2$ and $s_x = 0.0982(D - (0.9743/n))^3$

where “ D ” is the diameter of the rod in inches and “ n ” is the number of threads per inch.

No mortar, grout or concrete shall be placed between the bottom of the base plate and the top of the concrete

7. Soil friction angle and strength of soils shall be used when designing foundations. Foundations shall be designed in accordance with the requirements of the current AASHTO Standard Specifications for Highway Bridges. Foundation designs may require pilings, caissons, or special design as indicated by subsurface investigations (soil reports and boring logs) to establish soil capacity.
8. When caissons are used, the soil at the surface to a depth equal to the required diameter of the caisson, but not less than two (2) feet or as required by the conditions, shall not be considered effective when calculating the required embedment of the caisson. The ground surface slope shall be taken into account when determining caisson embedment.

An unfactored wind load shall be used in the analysis. Deflections and factors of safety for caissons shall be determined using actual wind loads not factored loadings.

For axial capacity the caisson tip elevation shall provide a length of caisson such that at least two thirds of the total predicted resistance is provided by shaft resistance. Total vertical deflection of the caisson head, from settlement and elastic shorting of the caisson, is limited to one (1) inch under service axial design loads.

The minimum area of longitudinal reinforcement for caisson type foundations shall be one percent of the gross area of the foundation section. In caissons where the wall post/beam is embedded to the bottom of the caisson, no reinforcement is required.

The required allowable stresses for steel and concrete in the caisson may be modified by the allowable overstress permitted in the wind load condition.

9. The Brom's method may be used for the design of laterally loaded caissons less than twenty (20) feet in length. For Group II and Group IV where wind is a contributing load, a minimum safety factor of 2.25 shall be used if soil parameters are based on the results of standard penetration tests. When parameters are based on the results of subsurface exploration and laboratory testing programs as detailed in the current AASHTO Standard Specifications for Highway Bridges, or are set by the Department, a safety factor of 2.0 may be used.

The preferred method of analyses for the design of laterally loaded caissons is the "p-y curve" method for the design and analysis of caissons under lateral loads, using public-domain computer program such as COM624P or commercially available software. The caisson embedment shall provide a length where the second point of zero deflection is reached. The second point of zero deflection may be assumed to be the point on the deflection curve where the deflection is decreasing and becomes less than 0.02 inch. The total horizontal deflection at the head of the caisson is limited to 0.5 inch.

Temporary casing may be used to stabilize a drill hole, however, the casing shall be removed immediately prior to or while placing the concrete. If the drill hole can not be maintained other methods, such as wet hole construction with slurry, shall be used.

If at the time of placing concrete, water in the hole exceeds five (5) feet or 20% of the caisson length, whichever is greater, the concrete shall be placed by pump or tremie.

10. For walls on spread footings, a bearing capacity analysis shall be submitted as part of the design calculations and the safety factor against bearing failure shall be taken as 2.25 for Group II and Group IV where wind is a contributing load. The ground surface slope shall be taken into account when determining bearing capacity of the soil. The depth of the embedment of footings shall be in accordance with the requirements of the aforementioned current AASHTO Standard Specifications for Highway Bridges.
11. For walls on piles, foundation design shall be in accordance with the requirements of the current AASHTO Standard Specifications for Highway Bridges. The factor of safety shall be on the level of construction control as required in Subsection 4.4.6.2. The required factors of safety may be modified by the allowable overstress permitted in the wind load condition.
12. Where new sound barrier walls tie into existing barriers existing sound barrier walls and other structures shall be analyzed to determine if they are adequate for the addition of new loads, if the Contractor chooses to use them for support. The Contractor shall make any field measurements and observations necessary to analyze the existing structures and detail all connections. Alternatively, the new wall may be designed independent of existing structures with details for closing gaps.
13. The Contractor shall submit to the Department nine (9) copies of the working drawings and supporting calculations in accordance with the requirements of Section 105.10 to:

Virginia Department of Transportation
Location and Design Division
Engineering Services
1401 E. Broad Street
Richmond, Virginia 23219

Working drawings shall contain all specific details and dimensions (such as post spacings, post sizes, foundation details, and panel fabrication and attachment details) necessary for the complete review, construction and inspection of the work. The working drawings for Sound Barrier Walls shall also reflect coordination with the working drawings for retaining walls or bridges or other adjacent construction items where applicable. Working drawings and the accompanying calculations shall be sealed by a Professional Engineer holding a valid license to practice engineering in the Commonwealth of Virginia. Calculations using computer programs or spreadsheets shall include a description of the design methodology necessary to validate the results of the computer output.

Any changes to the working drawings by the Contractor after the initial submittal shall be clearly identified. Changes shall be identified on the working drawings and denoted in narrative (e.g. cover letter) and dated after marking all requested changes. This format shall be followed until all requested changes are completed to the satisfaction of the Engineer. Approval of these shop drawing shall not relieve the Contractor of the responsibility for accuracy of the drawings or conformity with the contract and site requirements. Approval will not indicate a check on dimensions.

519.02—Materials

The Contractor may furnish plastic, metal, concrete or in specific applications, wood sound barrier walls. Walls shall conform to the requirements of the contract documents, AASHTO material specifications and the following applicable specifications. Wall system designs shall have been pre-approved for use by the Department. Requirements for evaluation and approval of sound barrier wall may be obtained from the Air, Noise, and Energy section of the Environmental Quality Division.

- (a) **Concrete** shall conform to the requirements of Section 217 and Sections 404 or 405 as applicable. Concrete for reflective sound barrier panels or concrete posts shall be Class A5. Concrete for footings or leveling pads shall be Class A3. All other concrete shall be Class A5 or Class A4. Sound absorptive concrete shall be considered a sound coating subject to other provisions in the specifications; the manufacturer's cited standards or proprietary materials. The use of systems employing such sound absorptive concrete materials shall require pre-approval of the Department.
- (b) **Reinforcing steel** shall conform to the requirements of Section 223. Reinforcing steel requiring welding shall be ASTM A706, Grade 60, and shall be welded in accordance with the current AWS D1.4. All other reinforcing steel shall be ASTM A615, Grade 60, or ASTM A706, Grade 60. Threads on reinforcing steel bars shall be UNC (coarse) Series, Class 2A as specified in ANSI B1.1. Welded wire fabric used to reinforce panels shall conform to the requirements of Section 223.
- (c) **Aluminum** shall conform to the requirements Section 229 for the use and shape specified. Welding of aluminum shall be performed in accordance with the requirements of the current AWS D1.2.
- (d) **Steel piles** shall conform to the requirements of Section 228. The portion of steel piles that serve as a post shall be galvanized in accordance with Section 233 above the finished grade and to a point 2 feet below the finished grade.
- (e) **Structural Steel** shall conform to the requirements of Sections 226 and 407, and shall be galvanized in accordance with the requirements of Section 233. Painting of structural steel shall be in accordance with the requirements of Section 411.
- (f) **Structural tubing** shall conform to the requirements of ASTM A500, Sections 226 and 407, and shall be galvanized in accordance with the requirements of Section 233. Structural tubing serving as posts is subject to Charpy V-Notch Impact test requirements in accordance with the requirements of Section 226.
- (g) **Miscellaneous steel** shall conform to the requirements of Sections 226 and 407, and shall be galvanized in accordance with the requirements of Section 233.
- (h) **Asphalt mastic** shall conform to and be applied in accordance with the requirements of AASHTO M243.
- (i) **Miscellaneous hardware** shall conform to the following: Anchor rods shall conform to the requirements of Section 226.02(c), and shall be galvanized in accordance with the requirements of Section 233. One nut and one washer shall be provided above and below the base plate at the connection to the anchor rods. The nut against the base plate shall be installed in such a way as to tension the anchor rod and create adequate friction between the nut and the

base plate. There shall be no play or slack in the connection of the anchor rods to the base plate after the nuts have been tightened. The distance from the underside of the base plate to the top of the concrete shall be no more than the diameter of the anchor bolt plus one inch.

Bolts, nuts, and washers shall be high strength and conform to the requirements of Section 226.02(h) and shall be galvanized in accordance with the requirements of Section 233. Self-drilling screws shall be Class 410 stainless steel conforming to the requirements of FS QQ-S-763 and shall be cadmium coated in accordance with the requirements of ASTM B766.

- (j) **Caulking sealant** shall conform to the requirements of FS TT-S-00230, TT-S-001543, or TT-S-001657. Exposed caulking shall be color-pigmented so as to match or be similar to the color of finished panels or as approved by the Engineer.
- (k) **Steel flashings and caps** shall be of the same material and thickness as the metal panels. Protective coating requirements shall be the same as those for panels.
- (l) **Elastomeric pads** shall conform to the requirements of ASTM D1056, Grade 1B3 C1, 1B4 C1, or 1B5 C1. Adhesives shall conform to the manufacturer's recommendations.
- (m) **Interlocking panels** shall conform to the following: Metal panels shall be of a cold-formed, trapezoidal-faced configuration. The covering width of the panel face shall be at least 12 inches. Each panel shall have a male and female rib providing a friction interlock connection with adjacent panels. The friction interlock connection shall provide sufficient connection when two connected panels are held in the same vertical and horizontal positions.
- (n) **Finish** - The sound wall panel finish of metal or plastic barrier shall be embossed or otherwise designed or treated to minimize light reflectance under wet conditions.
- (o) **Protective color coating** for metal panels shall be System No. 1 or System No. 2 as specified on the plans. When the system is not specified, System No. 1 shall be furnished. The coating system shall be flat in accordance with the Federal Standard Number(s) specified on the plans or as approved by the Engineer.
 1. **System No. 1** shall be either PVF plastic film (PVF₁) or urethane coating. System No. 1 coatings shall have an abrasion index of at least 16 liters per mil in accordance with the requirements of ASTM D968, shall be resistant to permanent graffiti markings, and shall produce an impervious finish free from cracks and crazings.
 - a. **PVF₁ shall have a thickness of at least 1.5 mils per coated side and shall be applied at the factory to the thoroughly cleaned and pretreated galvanized steel in accordance with the requirements of ASTM D2092, Method F. The PVF₁ film shall be pigmented to obtain optimum color performance and shall be laminated to the steel with heat and adhesive to produce a uniform, durable coating.**
 - b. **Urethane coating** shall be acrylic or polyester material with a chromate-bearing epoxy prime coat, shall have a thickness of at least 1.2 mils per coated side, and shall be applied at the factory to the thoroughly cleaned, pretreated, and galvanized steel sheets. The urethane coating shall be inorganically pigmented to obtain optimum color performance and oven cured under quality controlled conditions to produce a uniform and durable coating.

2. **System No. 2** shall be PVF (at least 70 percent resin) enamel (PVF₂) with a dry film thickness of at least 1 mil per coated side and shall be applied at the factory to thoroughly cleaned and pretreated galvanized steel in accordance with ASTM D2092, Method F. The PVF₂ enamel shall be pigmented to obtain optimum color performance and oven baked under quality controlled conditions to produce a uniform, durable coating free from cracks and crazings.
- (p) **Protective color coating** for concrete panels shall be a semiopaque toner containing methyl methacrylate-ethyl acrylate copolymer resins with toning pigments suspended in solution at all times by a chemical suspension agent and solvent. Color toning pigments shall consist of laminar silicates, titanium dioxide and inorganic oxides. There shall be no settling or color variation. The use of vegetable or marine oils, paraffin materials, stearates or organic pigments in the coating formulation will not be permitted.

Physical properties of the coating shall be as follows:

Weight per gallon	8.3 pounds (min.)
Solids by weight	30 percent (min.)
Solids by volume	21 percent (min.)
Drying time	30 minutes (max.) at 70°F and 50 percent humidity

Coating material shall not oxidize and shall show no appreciable change in color after 1000 hours when tested in accordance with ASTM D822; shall have excellent resistance to acids, alkalies, gasoline and mineral spirits when tested in accordance with ASTM D543; shall allow moisture vapor from the concrete interior to pass through when tested in accordance with ASTM E398 or D1653; and shall reduce the absorption rate of exterior moisture into the pores of the concrete surface when tested in accordance with Federal Specification TT-C-555 B.

Surface preparation, application rate and application procedures shall be as specified by the coating manufacturer, using airless spray equipment, having a minimum capacity of 1,000 psi and 1/2 gallon per minute. Coating shall not be applied when the air temperature is below 50°F, to damp surfaces or when the air is misty or unsatisfactory for this work as determined by the Engineer.

The sound wall color coating shall be from the Department's approved products list of materials for absorptive concrete sound wall color coatings.

- (q) Wood used for sound barrier walls shall conform to the requirements of Section 236 and shall be CCA preservative pressure treated with a minimum net retention of 0.60 pcf in accordance with American Wood Preservers Association UC4B. Panel design shall result in a sound transmission class of 38 or better when tested in accordance with the requirements of ASTM E90 or ASTM E413. Wood sound barrier walls shall be from the Department's approved barrier systems. The use of wood sound barrier systems shall be limited to those applications specifically identified on the plans or in the contract documents.
- (r) Plastic used in sound wall designs shall be of a high density, high impact resistant material such as, but not limited to; acrylic, fiberglass, polyethylene, polyvinylchloride, or polyurethane with antioxidant additives, UV stabilizers and capable of being produced with integral

color pigmentation where such color is identified by project plans. Plastic sound barrier systems shall be pre-approved by the Department for use.

519.03—Procedures

The Contractor shall design the wall when traversing a grade in such a manner that the finish profile of the top panels shall be as uniform in height as possible. The top face of the sound barrier wall shall be aligned to maintain a continuous appearance and shall not deviate from true alignment by more than 1/2 inch in 10 feet.

(a) Foundations

Existing ground line elevations shall be established and verified by the Contractor prior to submitting working drawings. The Contractor shall remove and dispose of all above ground obstruction such as trees and other clearing and grubbing items unless otherwise directed by the Engineer.

The Contractor shall adjust foundations to avoid conflicts with pipes or utilities. Wall panel lengths may be shortened or lengthened so that foundation locations may be adjusted to avoid conflicts and clear existing pipes, utilities, and other underground obstructions. When a conflict cannot be avoided using this method, the Contractor shall submit his alternative design for the Department's written approval. The Contractor shall modify the design of wall foundations where foundations may conflict with the limits of proposed or existing rights-of-way or where foundation designs may leave a portion of the foundation exposed above the finished ground line. Such conflicts and proposed modifications shall be reviewed with the Engineer prior to installation. Where sound barrier walls are self-supporting, they shall be designed to prevent pipe or utility damage caused by excessive bearing loads when placed over pipes, utilities, or other underground obstructions.

(b) Piles and Posts

Piles shall be driven in accordance with the requirements of Section 403 except that the tolerance for the position of a single steel H-pile shall be $\pm 1/2$ inch.

The portion of posts from the finished grade to the bottom end and the portion of the H-pile lapped with posts shall be painted with asphalt mastic after splicing. Voids between posts and piles created by the use of shims for plumbing posts shall be caulked prior to the application of asphalt mastic.

The Contractor may furnish the galvanized post and girts with the protective color-coating system specified for panels, thereby eliminating the related flashing covering, provided the posts and girts conceal threads of bolts and screws.

Structure-mounted sound walls shall have metal posts.

(c) Panels

1. General Requirements

The patching of panels will not be permitted without the written approval of the Engineer. Where patching is permitted by the Engineer, it shall be performed in accordance with the manufacturer's recommendations. Cut, marred, or scratched surfaces shall be repaired in accordance with the manufacturer's recommendations. Panels having deficiencies such as cracking, crazing, scaling, efflorescence, segregation, mottling of the color coating or stains on the finish shall be rejected. Irregularities at panel edges that appear broken, ragged, chipped or dented to the extent that a gap appears once they are stacked will be cause for rejection.

Sound absorptive coating shall be permanently bonded or attached to the panel's core material and have the same service life as the core materials.

The absorptive finish of concrete panels shall meet the requirements of ASTM C666, Procedure B, for 300 cycles

Where sound barrier panels do not occupy the full width between the flanges of the sound barrier posts, panel attachment details shall be furnished with the working drawings. Such details shall also include material descriptions. Post flanges and panels shall overlap at least 1 1/2 inches after installation. The face of the panel on the roadway side of the barrier shall fit tightly against the post flange for the full height of the panel after installation. Spacer blocks/wedges will not be permitted.

Joints and connections shall be secured so as to be structurally sound with no visible openings for sound transmission and shall not be a secondary source of noise attributable to vibration.

All lifting devices cast into panels shall be galvanized and flush with the panel.

2. Structure-Mounted Barriers

All structure-mounted sound barrier panels shall be metal or other pre-approved light-weight material. The bottom portion of the panels within 6 inches of the top of the parapet to which the wall is to be mounted shall not have an absorptive finish. The panels on structure-mounted sound barrier walls shall be oriented either vertically or horizontally to match any adjacent ground mounted sound barrier walls. Panel orientation shall be such that panels are free draining to prevent moisture buildup and possible corrosion. Structure-mounted sound barrier walls shall aesthetically match adjacent ground mounted barriers as to color unless stated otherwise in the contract. Anchor rods for structure-mounted walls shall be integrally cast into parapets. Concrete parapets or retaining walls shall not be slip formed when used as mounting structures for structure-mounted sound barrier walls. Connections between the panel and the posts and the sound barrier panel and the bridge shall account for the movement of the bridge as well as the expansion and contraction of the panels.

3. Ground-Mounted Barrier

Base Panels shall be a minimum height of 2 feet and shall be embedded in the ground a minimum of 6 inches to prevent sound leaks. A non absorptive durable finish is required on that portion of the base panels below ground and 6 inches above the ground line.

When panels are stacked, horizontal joints shall be aligned to create continuous horizontal lines; however, foundations and/or ground contact panels may be adjusted within the limits established herein to provide for the continuous horizontal alignment of joints. Horizontal joints formed where panels mate together and false or dummy joints (if present) must match in appearance and alignment. Once installed, the edges of stacked panels shall be neat, and sides that mate together shall be straight and true.

Reflective concrete sound barrier panels shall have all edges chamfered 3/4 inch or rounded to 1/2 inch radius. V-shaped control joints, $3/8 - 1/2$ inch deep, shall be scored into one side of panels less than 8 inches thick and both sides of panels 8 inches or more in thickness to control temperature and shrinkage cracking. These joints shall be no more than 8 feet on center.

All panel connection hardware and portions of metal base panels to be embedded in the ground shall be coated with asphalt mastic.

4. Sample Section

The Contractor shall erect a sample section of the ground-mounted wall at the job site prior to receiving final written approval to proceed with panel fabrication from the District office. The sample section shall be three bays of panels with posts to show how panels shall be secured to posts with attachment hardware. Sample panels shall show the attachment area formed in the panel. Sample panels shall show color and finishes of both sides of the wall.

(d) Drainage Requirements

Ground surface drainage shall be accommodated in the design. Sound barrier walls shall be designed to deter impoundment and trapping of water. Disturbed areas shall be graded in front and behind the sound barrier wall to control and dispose of roadway and slope drainage using a graded ditch or similarly functional drainage. The ground-mounted sound barrier posts and bottom sound barrier wall panel shall be designed with consideration for additional load created by the ditch slope where it rests against the wall.

Weep holes shall be provided in panels, where necessary, to facilitate proper drainage. Drainage design shall not create sound leaks.

Disturbed areas of earthwork shall be seeded in accordance with the requirements of Section 603.

(e) Other Detail Requirements:

1. **Concrete clear cover** over reinforcing steel, except precast concrete panels, shall not be less than 3 inches for primary reinforcement and 2 1/2 inches for ties and stirrups. Concrete clear cover shall not be less than 1 1/2 inches for precast concrete panels. Concrete clear cover excludes any sound absorptive concrete finish.
2. **Steel reinforcement** shall be designed to resist in-service loads as described in 519.01(b) and handling loads resulting from manufacture, transport and installation. All concrete elements shall have at least enough reinforcement to satisfy the requirements in article 8.20, "Shrinkage and Temperature Reinforcement," afore-

mentioned AASHTO specifications. Mechanical butt spliced connections shall develop at least 125% of the tensile yield strength of the bar. If welds are necessary, they shall be detailed on the working drawings.

3. **Anchor rods** shall be embedded into concrete a distance equal to or greater than the development length of an equivalent reinforcing steel bar in accordance with the article 8.25, "Development of Deformed Bars and Deformed Wire in Tension," AASHTO Standard Specifications for Highway Bridges. Hooked anchor rods shall not be used to reduce the embedment length. Anchor rods shall be enclosed in reinforcing steel ties over their full embedded length. These ties shall not be spaced more than 12 inches on center and shall not be less than #3 in size. A minimum of four anchor rods shall be used per post if the anchor rods have adequate capacity to resist 150% of the design loads; otherwise a minimum of six anchor rods shall be used per post. Anchor rods shall not be heated or bent in the field to accommodate misalignment of anchor rods without approval of the Engineer. Anchor rods, washers and nuts of ground mounted sound barrier walls shall be coated with asphalt mastic both above and below base plates after installation.
4. **Epoxy or adhesive anchors, expansive anchors, split washers, and lock nuts** shall not be allowed. Multiple washers shall not be allowed as spacers for bolted connections or anchor rods.
5. **Base panel leveling pads** (support blocks), where needed, shall be cast-in-place reinforced concrete with steel dowels embedded in the concrete foundation.
6. **Precast concrete members**, including panels, shall not be lifted from casting beds until their design compressive strength is sufficient to prevent damage. Concrete shall have attained the minimum 28-day design compressive strength before members are shipped to the project site. During storage, stacked members shall be separated from each other by wood spacing blocks. Curing, storing, transporting, and handling of precast members shall be done in such a manner as to avoid excessive bending stresses and to prevent cracking, spalling, chipping or other damage. Units damaged by improper storage or handling shall be replaced at the Contractor's expense. Acceptable lifting and support points and directions of reactions shall be shown on the working drawings. The Contractor shall be responsible for the design and safety of the lifting devices used. Embedded lifting inserts and devices shall be steel and galvanized in accordance with the requirements of Section 233. Computations accompanying the working drawings shall demonstrate that stresses in the member are within the allowable range during shipping, handling, and installation using appropriate impact factors.
7. **Grout** between the base plate and concrete shall not be used.

519.04—Measurement and Payment

Sound barrier walls will be measured in square feet of surface from the finished grade to the sound attenuation line shown on the plans and from end to end of the wall, complete-in-place, and will be paid for at the contract unit price per square foot. The six inch minimum embedment in the ground of all base panels of ground mounted sound barrier walls will be considered incidental and will not be measured for separate payment. Structure-mounted sound barrier walls shall be measured in square

feet of surface from the top of the parapet or mounting structure to the sound attenuation (noise abatement) line shown in the plans. This price shall include designing, furnishing; installation; providing modifications to avoid utility, Right-of-Way, foundation exposure, and tie-back conflicts; grading, seeding; disposing of surplus and unsuitable material; restoring property; and construction outside the grade or sound attenuation line. Excavation of tree roots, existing limited access fence and other clearing and grubbing items such as those identified in Section 301 required for the placement of walls shall be included in the square foot price bid of the sound barrier walls. The cost of foundation designs and supplemental geotechnical investigation and foundations shall be considered incidental and will not be measured for separate payment but shall be included in the price bid per square foot of sound barrier wall. Costs for ultrasonic and radiographic testing and all other quality control measures required by the specifications shall be included in the price bid per square foot of sound barrier wall.

After the second submittal of working drawings, costs for review shall be in accordance within the provisions of Section 105.10

Payment for sound barrier walls shall be made incrementally as construction progresses in accordance with the following percentages: 20 percent of the contract unit square foot price after completion of wall design and submission acceptance, 20 percent of contract unit square foot price after construction and installation of foundations and posts including posts caps, and geotechnical/subsurface investigation, testing where specified and if applicable, 45 percent of contract unit square foot price after installation of panels, and 15 percent of contract unit price after completion of sound barrier wall and color coating, if specified.

Where multiple walls are specified in the contract, incremental payments will not apply to individual walls but to all walls specific to the individual pay items listed.

Sound wall color coating will be paid for at the contract unit price per square yard, which price shall be full compensation for furnishing and applying the sound wall color coating, surface preparation and for all materials, labor, tools, equipment and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
Sound barrier wall, absorptive	Square foot
Sound barrier wall, reflective	Square foot
Structure-mounted sound barrier wall, absorptive	Square foot
Structure-mounted sound barrier wall, reflective	Square foot
Sound wall color coating	Square yard

SECTION 520—WATER AND SANITARY SEWER FACILITIES

520.01—Description

This work shall consist of furnishing and installing necessary materials for water distribution systems and sanitary systems in accordance with these specifications and in conformity to the dimensions, lines, and grades shown on the plans or as established by the Engineer.

520.02—Materials

- (a) **Pipe, fittings, and flanges** shall conform to the requirements of Section 232.
- (b) **Gaskets and joint materials** shall conform to the requirements of Section 212.
- (c) **Casing pipe** shall be 14-gage corrugated metal half-circle pipe conforming to the requirements of Section 232 except as modified for securing interlocked or nested connections.
- (d) **Concrete blocks** shall conform to the requirements of Section 222.
- (e) **Bricks** shall conform to the requirements of Section 222.
- (f) **Hydraulic cement mortar** shall conform to the requirements of Section 218.
- (g) **Concrete** shall conform to the requirements of Section 217 and shall be Class A3.
- (h) **Reinforcing steel** shall conform to the requirements of Section 223.
- (i) **Curing material for concrete** shall conform to the requirements of Section 220.
- (j) **Timber skids** shall conform to the requirements of Section 236, and the preservative and treatment shall conform to the requirements of Section 236.
- (k) **Valves** shall conform to the requirements of AWWA C500, C504, C506, C507, C508, or C509 for the types and features specified.
- (l) **Fire hydrants** shall conform to the requirements of AWWA C502 or C503 with the various features specified.
- (m) **Water meters** shall conform to the requirements of AWWA C700, C701, C702, C703, C704, C706, C707, C708, or C710 for the type and features specified. Each meter shall be furnished with a meter box.
- (n) **Corporation stops** shall be made of bronze or red brass conforming to the requirements of ASTM B62. The fitting design and thread dimension shall conform to the requirements of AWWA C800. The working pressure of the corporation stop shall be equal to that of the water main to which it is attached.
- (o) **Castings** shall conform to the requirements of Section 224.
- (p) **Nonshrink waterproof grout** shall conform to the requirements of Section 218.
- (q) **Aggregate** shall conform to the requirements of Section 203. Aggregate for drain fields shall be No. 5.

520.03—Procedures

The Contractor shall be responsible for anticipating and locating underground utilities and obstructions in accordance with the requirements of Section 105.08.

When construction appears to be in close proximity to existing utilities, the trench(es) shall be opened a sufficient distance ahead of the work or test pits made to verify the exact locations and inverts of the utility to allow for changes in line or grade.

Connections to existing lines shall be made only after the proposed line is completed and approved by the Engineer. Connections shall be made in the minimum time possible with minimum interruption of service. Work and interruptions in existing service shall be scheduled with the utility owner.

Existing water and sewer lines and appurtenances and manholes not required in the completed system shall be abandoned as directed by the Engineer. Abandoned materials shall become the property of the Contractor, unless otherwise noted on the plans, upon satisfactory replacement with the new installation. Abandoned pipe that is not removed shall be cleaned of debris and plugged at open ends with Class A3 concrete.

Existing manholes that are not required in the completed system shall be removed to at least 2 feet below the proposed subgrade or natural ground line and shall be filled with approved backfill in accordance with the requirements of Section 302.03 (a)2.g.

Disturbed property shall be restored prior to final acceptance. Restoration shall include, but not be limited to, replacing shrubbery, sod, or topsoil, including lime, fertilizer, seed, and mulch; replacing paved or finished surfaces with similar materials; and performing other work in accordance with the requirements of Section 107.08.

Sidewalks and streets shall be kept open for passage. The Contractor shall provide and maintain adequate and safe passage over excavations to accommodate pedestrians or vehicles as directed by the Engineer.

- (a) **Protecting Water Supplies:** During the course of construction, the Contractor shall protect water supply facilities within the construction limits from contamination by sewage. The Contractor shall use the following criteria to govern the installation of water and sewer facilities in proximity of each other:
1. **Parallel separation:** Except as specified hereinafter, water lines shall be placed at least 10 feet horizontally from existing or proposed sanitary sewer lines, combination sewer lines, and sanitary sewer manholes. Sanitary sewer lines shall be placed at least 10 feet horizontally from existing and proposed water lines. This distance shall be measured from edge to edge. If local conditions prevent a lateral separation of 10 feet, a water line may be placed closer than 10 feet to a sewer or a sewer line may be placed closer than 10 feet to a water line if the top of the sewer pipe is at least 18 inches below the bottom of the water line. Where the vertical separation cannot be obtained, the sewer shall be constructed of mechanical joint water pipe. Gravity sewers shall be pressure tested, in place, to 50 pounds per square inch without leakage prior to backfilling. Force main sanitary sewer shall be pressure tested in accordance with the requirements of Section 520.04(c).
 2. **Crossings:** Water and sewer lines that cross shall be placed to provide a separation of at least 18 inches between the bottom of the water line and the top of the sewer line. Where this vertical separation cannot be obtained, the sewer shall be constructed of mechanical joint or other approved water pipe for at least 10 feet on each side of the crossing.

Sanitary sewers and combined sewers crossing over a water line shall have a vertical separation of at least 18 inches between the bottom of the sewer and the top of the water line. The support shall be adequate to prevent excessive deflection of joints and the settling on and breaking of the water line. The water or sewer line shall be centered at the point of the crossing so that joints will be equidistant and as far from each other as practicable.

Water lines shall not pass through or come in contact with any part of a sanitary sewer, combined sewer, or sanitary sewer manhole.

The Contractor shall immediately notify the Engineer if he becomes aware that the work will result in the violation of these criteria. Upon such notification, the Engineer will issue instructions concerning remedial measures.

- (b) **Excavation:** Excavation, backfill, and compaction shall be performed in accordance with the requirements of Section 302 except that stone larger than 1 inch in diameter shall not be used in backfill until the pipe has a cover of at least 1 foot. The remainder of backfill to the original ground or to within 12 inches of the finished subgrade shall not include stone larger than 10 inches in its greatest dimension. Pipelines installed outside the roadway shall be backfilled in 8-inch layers and compacted to approximately 85 percent of the theoretical maximum density.

Trenches for pipelines shall be excavated generally along straight lines, and bottoms shall be uniformly graded as required. Bedding material shall be placed in accordance with the plans. Where the trench bottom is in rock, it shall be excavated to at least 8 inches below the bottom of the pipe and backfilled with approved local or commercial bedding material. Pipe shall have a uniform bearing on a solid foundation for its entire length. Where pipe foundations are yielding, pipe shall be bedded on at least 8 inches of approved local or commercial bedding material. Bell holes, where applicable, shall be of sufficient size to ensure the making of proper joints.

Trenches below the grade line of the pipe shall be dewatered during installation of pipelines.

When work is not in progress for any reason, lines shall be securely closed.

Where adjacent pavements are to be retained, pavement removed for pipeline trenches shall be replaced in kind with equal or better material or as otherwise specified. After backfilling, the Contractor shall maintain a smooth riding surface until pavement repairs are completed.

- (c) **Inspecting Pipe and Fittings:** Pipe and fittings shall be inspected for cracks and defects before they are lowered into the trench. Faulty pipe and fittings shall be removed from the site.
- (d) **Placing Pipe:** Water mains shall have a cover of at least 36 inches, and water service lines shall have a cover of at least 24 inches. Pipe, fittings, valves, hydrants, and accessories shall be carefully lowered into the trench to prevent damage to materials, protective coatings, and linings. Materials shall not be dropped or dumped into the trench.

If pipe, fittings, valves, hydrants, or accessories are damaged during handling, the damage shall be immediately brought to the Engineer's attention. The Contractor shall then submit

to the Engineer, for approval, a method for repairing the damaged item. Damaged items shall be repaired as approved by the Engineer or shall be removed from the project.

Lumps, blisters, and excess coating shall be removed from ends of pipes that are to be joined. The inside of the bell and the outside of the spigot shall be wire brushed, wiped clean, dry, and free from oil and grease before pipe is placed. Foreign material shall be kept from entering pipe during placement.

As each length of pipe is placed in the trench, the spigot end shall be centered in the bell and the pipe forced home and brought to the correct line and grade. Pipe shall be secured in place with approved backfill material tamped under it except at bells. Precautions shall be taken to prevent dirt from entering the joint space. If it becomes necessary to deflect water main pipe during construction, the amount of deflection shall not exceed the manufacturer's recommendation.

- (e) **Cutting Pipe:** Pipe for fittings or closure pieces shall be cut in a neat and orderly manner without damage to the pipe so as to leave a smooth end at right angles to the axis of the pipe. The lining of the pipe shall not be damaged. Flame cutting of ductile iron or cast iron pipe with an oxyacetylene torch will not be permitted.
- (f) **Joining of Pipe:** Gasket and joint lubricant for water facilities shall be a nontoxic, tasteless, and odorless substance that will not support bacteria. Gasket end joint lubricant for sewer facilities shall be as recommended by the manufacturer or as approved by the Engineer. Pipe that is not furnished with a depth mark shall be marked before assembly to ensure that the spigot end is inserted to the full depth of the joint. Field-cut pipe lengths shall be filed or ground to resemble the spigot end of such pipe as manufactured.
 1. **Ductile iron pipe** shall be joined in accordance with AWWA C-111 and AWWA C-600.
 2. **Steel pipe** shall be joined by field welding unless otherwise specified on the plans. Pipe ends shall comply with the requirements of AWWA C-206 for the type of field joint specified. Field-welded joints shall comply with the requirements of AWWA-206; flanged joints shall comply with the requirements of AWWA C-207, and rubber gasket joints shall comply with the requirements of AWWA M11.
 3. **Galvanized steel pipe** shall be joined by fittings in accordance with the manufacturer's recommendation.
 4. **Copper pipe or tubing** shall be joined by fittings in accordance with the manufacturer's recommendation.
 5. **PVC pipe** shall be joined by gasketed bell and socket joints in accordance with AWWA C-900.
 6. **Concrete pipe** for water facilities shall have joints of the round rubber gasket type, unless otherwise specified, using either a bell and spigot joint or a double spigot and sleeve joint. Either joint shall be such that when the pipe is laid and the joint completed, the gasket will be confined within a groove or by shoulders on the bell and spigot. The contact surface in the joint shall be such as not to cause cutting of the rubber gasket during installation.

Concrete pipe for sewer facilities shall be joined by using rubber gaskets. The gasket shall be continuous and fit snugly into the annular space between the overlapping surfaces of the assembled pipe joint to form a flexible watertight seal. The annular space between the gasket bearing surface of the assembled and centered joint shall be more than 75 percent of the uncompressed thickness of the applied gasket including the manufacturer's tolerances of the joint and gasket.

7. **Vitrified clay pipe** shall be joined with compression joints in accordance with ASTM C-12 and manufacturer's recommendation.
 8. **PE pipe** shall be joined in accordance with AWWA C-901 and the manufacturer's recommendation.
 9. **ABS pipe** shall be joined with a solvent cement joint in which pipe solvent cements into a coupling socket to form the joint. Primer for priming solvent cement joints shall be methylethyl ketone (MEK), and the cement shall be MEK containing a minimum of 20 percent by weight of dissolved ABS. Type OR joint is a mechanical-seal joint in which a gasket shall be compressed between the pipe and the bell coupling to form the joint closure.
- (g) **Plugs, Caps, Tees, and Bends:** Plugs, caps, tees, and bends shall be anchored with reaction backing. Backing shall be concrete reaction blocks, metal reaction harnesses, or a combination thereof. Concrete shall be placed in accordance with the requirements of Section 404 and cured in accordance with the requirements of Section 316.04(j). Metal harness tie rods and clamps shall be of adequate strength to prevent movement and shall be galvanized or rustproofed by approved means.
 - (h) **Encasement Pipe:** Encasement pipe shall be installed in accordance with the requirements of Section 302.
 - (i) **Casing Pipe and Concrete:** Casing pipe and concrete shall be constructed in accordance with plan details and the applicable requirements of Sections 302, 303, 316, and 406, with the half-circle sections of casing pipe nested or interlocked to obtain a satisfactory union of the two sections of pipe. Prior to installation, existing pipe to be encased shall be cleaned and foreign material removed.
 - (j) **Valves, Valve Boxes, and Manholes:** The valve box shall not transmit shock or stress to the valve and shall be centered and plumb over the wrench nut of the valve with the box cover flush with the surface of the finished pavement. Manholes shall be constructed to permit minor valve repairs and protect the valve and pipe from impact where they pass through the walls.
 - (k) **Fire Hydrants:** Wherever a hydrant is set in pervious soil, drainage shall be provided at the base of the hydrant by placing coarse gravel or crushed stone mixed with coarse sand from the bottom of the trench to at least 6 inches above the waste opening in the hydrant and to a distance of 1 foot around the elbow.

Wherever a hydrant is set in clay or other impervious soil, a drainage pit 2 feet in diameter and 3 feet in depth shall be excavated below each hydrant. The pit shall be filled compactly with coarse gravel or crushed stone mixed with coarse sand under and around the elbow of

the hydrant to a level 6 inches above the waste opening. The drainage pit shall not be connected to a sewer.

- (l) **Installing Corporation Stops:** Corporation stops shall be installed while the main is under pressure and at a 45-degree angle to the horizontal plane.
- (m) **Concrete Encasement:** Concrete encasement shall be constructed in accordance with the requirements of Sections 302, 303, 316.04(j), 404, and 406.
- (n) **Water Meters and Yokes:** The meter box shall not transmit shock or stress to the meter and shall be centered and plumb over the meter. The top of the box shall be flush with the surrounding surface.
- (o) **Jacked Encasement Pipe:** Jacked encasement pipe shall be installed in accordance with the requirements of Section 302.03(a)1.
- (p) **Sanitary Service Lateral Connection:** Connection shall be performed by approved methods prior to installation using wyes, bends, adapters, cleanouts, and necessary pipe. Existing service laterals shall mate with the new fitting, adapter, or pipe to produce a watertight joint.
- (q) **Sanitary Manholes and Manhole Frames and Covers:** These items shall be constructed in accordance with the requirements of Section 302.03(c). A secure bond between the pipe and manhole wall shall be obtained. Flexible insert gaskets shall be used to obtain a watertight joint. The gasket style and composition shall be subject to the approval of the Engineer. Precast wall sections shall be seated with flexible joint sealant for their full circumference. Lift holes, defects, joints between sections, and frames and covers shall be sealed with nonshrink waterproof grout.
- (r) **Sanitary Drop Connections:** Connections shall be constructed in accordance with the requirements of Sections 302, 303, 404, and 406.
- (s) **Sewer Cleanouts:** Cleanouts shall be constructed in accordance with the requirements of Sections 302, 303, 404, and 406.
- (t) **Conveying Sewage:** When it is necessary to contain or pump sewage during the adjustment of or connection to existing sewers, sewage shall be carried by a watertight conveyor to sewers or manholes approved by the Engineer or shall be disposed of in accordance with local and state health codes. Sewage shall not be allowed to flow onto or over any open surface.
- (u) **Manhole Frame and Covers, Valve Boxes, and Other Castings Located Within the Paved Roadway, Shoulder, or Sidewalk:** These shall be constructed within a tolerance of ± 0.05 foot of the finished grade.
- (v) **Reconstruct Existing Sanitary Manhole:** This shall consist of the removal of the existing manhole to the point indicated on the plans or directed by the Engineer. Reconstruction shall be accomplished by using existing units and pavement rings or new units and adjustment rings to attain the proposed finished grade.

520.04—Testing

Water and sewer mains, appurtenances, and materials shall be tested for leakage after installation. Testing shall be performed in the presence of the Engineer. The Contractor shall provide water, plugs, equipment, tools, labor, materials, and incidentals necessary to perform the testing. If any section of a main or manhole under test shows leakage in excess of that specified, the Contractor shall make necessary repairs or replacements at his own expense. Testing shall be repeated until satisfactory results are obtained. Visible leaks shall be repaired regardless of the amount of allowable leakage.

- (a) **Water Mains and Appurtenances:** New water mains and appurtenances shall be tested for leakage using the hydrostatic pressure test method in accordance with Section 4 of AWWA C600 and the following:
1. The duration of each test shall be at least 2 hours. Sections of main with concrete reaction backing shall not be tested until at least 5 days after the backing is placed. If the backing is high-early-strength concrete, the test may be performed 2 days after backing is placed.
 2. Testing of tie-ins with existing mains shall be performed under the normal working pressure of the main involved. Visible leakage at these points will not be allowed during a period of at least 2 hours.
 3. The hydrostatic test pressure shall be 100 pounds per square inch or 1.5 times the working pressure, whichever is greater, based on the elevation of the lowest point in the line or section under test and shall be corrected to the elevation of the test gage. The Contractor shall ascertain the specific working pressure of the water main from the utility owner. Leakage loss shall not exceed the allowable leakage (L) as determined by the following formula:

$$L = \frac{ND \bar{P}}{7,400}$$

Where:

L = the allowable leakage in gallons per hour;

N = the number of joints in the length of pipe line tested;

D = the nominal inside diameter of the pipe in inches; and

P = the average test pressure during the leakage test in pounds per square inch.

- (b) **Gravity Sanitary Sewers:** Leakage shall be not more than 200 gallons per inch of pipe diameter per mile per day (24 hours) for pipe up to and including 24 inches in diameter and not more than 4,800 gallons per mile per day for pipe more than 24 inches in diameter for any section of the system, including manholes, when subjected to at least 4 feet of head above the line crown at the upstream manhole of the section being tested.
1. **Infiltration test:** When in the opinion of the Engineer the trench or excavation is sufficiently saturated as a result of natural ground water, tests may be made on the basis of infiltration. The Contractor shall measure the flow of water at the nearest downgrade manhole. Three series of measurements shall be made at not less than 1-hour intervals, and the results shall be reduced to an average. The average for a 24-hour period shall then be computed. If the pipeline or manholes fail to meet the test requirements, leaks

shall be repaired and defective pipe and manholes shall be replaced at the Contractor's expense. The test shall be repeated until satisfactory results are obtained.

2. **Exfiltration test:** An exfiltration test shall be performed when the trench or excavation is dry and infiltration will not occur. The test shall be conducted as follows: The pipe shall be plugged at the lower manhole. The line and manhole shall be filled with water to a 4-foot level or to the top of the straight section if the manhole is less than 4 feet in height. The water shall stand until the pipe has reached maximum absorption and until trapped air has escaped (at least 4 hours). After maximum absorption has been reached, the manhole shall be filled to the original level. After 1 hour has elapsed, the difference in the level shall be recorded in terms of gallons. The 24-hour loss shall then be computed. If the pipe line system and manholes fail to meet test requirements, leaks shall be repaired at the Contractor's expense. The test shall be repeated until satisfactory results are obtained.

3. **Air test:** In lieu of the infiltration or exfiltration test for leakage, the Contractor may test the sewers by using low air pressures. In the event low air pressure tests are used, the manholes shall be tested by exfiltration. Inflatable stoppers shall be used to plug all lines into and out of the manhole being tested. The stoppers shall be positioned in the lines far enough from the manhole to ensure testing of those portions of the lines not air tested. The manhole shall then be filled with water to the top and a 12-hour soaking period shall be allowed prior to test measurement. The manhole shall be refilled to a mark, and at the end of 1 hour, the amount of leakage shall be measured. Leakage shall not exceed 1/2 gallon per hour. If the manhole fails to comply with the test requirements, leaks shall be repaired at the Contractor's expense. The test shall be repeated until satisfactory results are obtained. The low air pressure test shall be conducted in accordance with the following:
 - a. After backfilling and prior to air testing, the Contractor shall eliminate discernable water leaks and remove debris. Tests shall be conducted from manhole to manhole or from manhole to terminus. Personnel shall not be allowed in manholes once testing has begun.
 - b. Immediately before testing, the Contractor shall provide securely braced test plugs at each manhole and a suitable means of determining the depth of the ground water level above the inverts.
 - c. The Contractor shall slowly add air to the portion of the pipe being tested until the internal air pressure is at a test pressure of 4 pounds per square inch above the invert or ground water table, whichever is greater, or until the pressure is equal to the hydraulic gradient, whichever is greater. If the test plug shows leakage, as determined by the Engineer, the Contractor shall relieve the pressure for at least 2 minutes. The Contractor shall then disconnect the hose and compressor. If the pressure decreases to 3.55 pounds per square inch, the time shall be recorded for the amount of time required for the pressure to drop from 3.5 to 2.5 pounds per square inch. The minimum allowable holding times will be as specified herein. Pipes that fail to maintain minimum holding times will not be accepted. Repairs, replacement, and retesting as specified by the Engineer shall be performed at the Contractor's expense.

The minimum allowable holding time for an 8-inch sanitary sewer pipe that is required for the pressure to drop from 3.5 to 2.5 pounds per square inch is:

Line Length	Time (sec)
25	18
50	35
75	53
100	70
125	88
150	106
175	123
200	141
225	158
250	176
275	194
300	211
350	227
400	227

The minimum allowable holding time for a 12-inch sanitary sewer pipe that is required for the pressure to drop from 3.5 to 2.5 pounds per square inch is:

Line Length	Time (sec)
25	40
50	79
75	119
100	158
125	198
150	238
175	277
200	317
225	340
250	340
275	340
300	340
350	340
400	340

- (c) **Force Main Sanitary Sewers:** Leakage shall not exceed the allowable leakage (L) as determined by the following formula:

$$L = \frac{ND \bar{P}}{1850}$$

Where:

L = the allowable leakage in gallons per hour;

N = the number of joints in the length of pipe line tested;

D = the nominal inside diameter of the pipe in inches; and

P = the average test pressure during the leakage test in pounds per square inch.

The hydrostatic test pressure shall be maintained for at least 30 minutes at 100 pounds per square inch or 1.5 times the working pressure, whichever is greater, based on the elevation of the lowest point in the line or section under test and shall be corrected to the elevation of the test gage. The Contractor shall ascertain the specific working pressure of the force main from the utility owner. Visible leaks shall be satisfactorily repaired regardless of the amount of allowable leakage.

- (d) **Offsets of Existing Pipe:** Offsets will not be subjected to hydrostatic pressure testing unless specified on the plans. After installation and connection to the existing mains, the offset shall be placed in service and left uncovered for visual inspection for at least 2 hours. Visible leaks shall be repaired to the satisfaction of the Engineer prior to acceptance of the offset. Offset of existing pipe for water mains shall be disinfected in accordance with AWWA C-651, Section 9.

520.05—Disinfecting Water Mains

New, relocated, and modified water mains and accessories shall be disinfected prior to tie-ins in accordance with AWWA C651.

If the initial disinfection fails to yield satisfactory samples, disinfection shall be repeated until satisfactory samples have been obtained. After each group of samples is taken, the Contractor shall submit a written report to the Engineer that states the results of the tests.

520.06—Measurement and Payment

Excavation and replacement of pavement removed for pipe trenches will not be measured for separate payment unless otherwise shown. However, minor structure excavation will be measured and paid for in accordance with the requirements of Section 303.06. When excavation is required below the proposed trench bottom, necessitating additional bedding material, the bedding will be measured and paid for in accordance with the requirements of Section 302.04.

Water mains, water service lines, sanitary sewer pipe, and sanitary sewer force mains will be measured in linear feet of pipe through all valves and fittings, complete-in-place, and will be paid for at the contract unit price per linear foot. This price shall include excavating when not a specific pay item for the utility in question; testing; disinfecting; backfilling; compacting; dewatering; disposing of surplus and unsuitable material; sheeting and shoring; bedding material; installing pipe; connecting to existing lines or manholes; fittings less than 16 inches in diameter; reaction blocking; concrete anchor block; watertight welds; restrained joints; abandoning or removing lines, manholes, and other appurtenances; and restoring property. Pipe of one size, except for cast iron and ductile iron pipe, shall be combined into one contract item for the respective size of water main and sanitary sewer pipe. The salvage value of abandoned materials shall accrue to the Contractor and shall be reflected in the contract unit price for the respective replacement facility.

Encasement pipe and casing pipe and concrete will be measured in linear feet, complete-in-place, and will be paid for at the contract unit price per linear foot. This price shall include excavating, dewatering, sheeting and shoring, blocking, installing pipe, grouting, concrete encasement, reinforcing

steel, masonry blocks, watertight bulkheads, backfilling, compacting, disposing of surplus and unsuitable material, and restoring property.

Jacked encasement pipe will be measured and paid for in accordance with the requirements of Section 302.04. This price shall include excavating, backfilling, disposing of surplus and unsuitable material, sheeting and shoring, blocking, bulkheads, and jacking.

Concrete encasement will be measured in linear feet of encased pipe or cubic yard of concrete, complete-in-place, and will be paid for at the contract unit price per linear foot or cubic yard. This price shall include excavating, sheeting and shoring, concrete, reinforcing steel, backfilling, compacting, and disposing of surplus and unsuitable material.

Sanitary service lateral connections will be measured in linear feet, complete-in-place, from the center line of the sewer main to the point of connection of sanitary service lateral and will be paid for at the contract unit price per linear foot. This price shall include excavating, backfilling, compacting, disposing of surplus and unsuitable material, sheeting and shoring, connecting to existing service lateral, and restoring property.

Sanitary drop connections will be measured in linear feet, vertical measure, complete-in-place, from the invert of the upper inlet pipe to the invert of the lower inlet pipe and will be paid for at the contract unit price per linear foot. This price shall include pipe and fittings, concrete, reinforcing steel, connections to sewer lines and manholes, excavating, bedding material, backfilling, compacting, disposing of surplus and unsuitable material, and restoring property.

Sanitary sewer manholes, frames and covers, and watertight frames and covers will be measured and paid for in accordance with the requirements of Section 302.04.

Sewer cleanouts (main or lateral) will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each. This price shall include fittings; riser pipe, frame, cover, and box; excavating; backfilling; compacting; disposing of surplus and unsuitable material; and restoring property.

Reconstruct existing sanitary manhole will be measured in linear feet, vertical measure, from the point of the removed section to the top of masonry on which the frame and cover is placed and will be paid for at the contract unit price per linear foot. This price shall include removing, salvaging and re-setting frame and cover, reconstruction of manhole, new materials, excavation, backfilling, compaction, disposal of surplus of unsuitable material and restoring property.

Fire hydrants will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each. This price shall include excavating, dewatering, backfilling, compacting, connections, concrete blocking, pipe straps, crushed stone drain, disposing of surplus and unsuitable material, restoring property, and testing.

Water meters and boxes; water meter boxes and yokes; valves and boxes or manholes; and tapping sleeves, valves, and boxes or manholes will be measured in units of each, complete-in-place, and will be paid for at the contract unit price per each. This price shall include excavating, backfilling, and restoring property.

Bends, plugs or caps, reducers, and branches (tees, wyes, and crosses) will be measured in units of each and will be paid for at the contract unit price per each. This price shall include restrained joints,

excavating, reaction blocking, testing, backfilling, sheeting and shoring, watertight welds, abandoning or removing existing lines as noted on the plans, and restoring property.

Offsetting existing pipe will be measured in linear feet of pipe parallel to the flow line between tie-in points, complete-in-place, and will be paid for at the contract unit price per linear foot. This price shall include fittings, couplings, restrained joints, excavating, testing, disinfecting, backfilling, compacting, dewatering, disposing of surplus or unsuitable material, sheeting and shoring, bedding material, installing pipe, connecting existing lines as noted on the plans, reaction blocking, watertight welds, abandoning or removing existing lines as noted on the plans, and restoring property.

Leak detectors will be measured in units of each. This price shall include pipe, return bends, bird screens, clamps, excavating, backfilling, and restoring property.

These prices shall include containing or pumping sewage during adjusting or connecting existing sewers and providing and maintaining adequate and safe passage over excavations to accommodate pedestrians or vehicles as directed by the Engineer.

Payment will be made under:

Pay Item	Pay Unit
Water main (Size and type)	Linear foot
Water service line (Size)	Linear foot
Encasement pipe (Size and type)	Linear foot
Casing pipe and concrete (Size)	Linear foot
Leak detector (Standard)	Each
Bend (Size)	Each
Reducer (Size)	Each
Plug or cap (Size)	Each
Branch (Size)	Each
Offset existing pipe (Size)	Linear foot
Valve and (box or manhole) (Size and type)	Each
Tapping sleeve, valve, and (Box or manhole)	Each
Fire hydrant (Standard and type)	Each
Water meter and box (Size)	Each
Water meter box and yoke (Size)	Each
Jacked encasement pipe (Size and type)	Linear foot
Sanitary sewer pipe (Size and type)	Linear foot
Sanitary service lateral connection (Size)	Linear foot
Sanitary sewer force main (Size)	Linear foot
Bend-force main (Size)	Each
Reducer-force main (Size)	Each
Plug or cap-force main (Size)	Each
Branch-force main (Size)	Each
Offset existing pipe-force main (Size)	Linear foot
Sanitary sewer manhole (Standard)	Linear foot
Manhole frame and cover (Standard)	Each
Sanitary drop connection	Linear foot
Valve and (box or manhole) (Size and type)-force main	Each
Tapping sleeve, valve, and (box or manhole) (Size)-force main	Each

Pay Item	Pay Unit
Concrete encasement (Standard)	Linear foot or Cubic yard
Reconstruct existing sanitary manhole	Linear foot
Watertight manhole frame and cover (Standard)	Each

SECTION 521—MAILBOX POST

521.01—Description

This work shall consist of replacing mailbox posts shown on the plans or designated as hazardous objects by the Engineer.

521.02—Materials

Post and mounting hardware shall conform to Standard Drawing RFD-1.

521.03—Procedures

The Contractor shall be responsible for damages incurred through negligence to existing mailboxes not designated for replacement during their removal, at their temporary location, and during resetting in accordance with the requirements of Section 105.15.

The placement and installation of the mailbox to be replaced shall be in accordance with Standard Drawing RFD-1 and the Department's Asset Management Division's *Best Practices Manual*.

Mailbox post types shall be single, double, or multiple.

The property owner may elect to furnish a new mailbox in lieu of remounting the existing mailbox, in which case the installation shall be at no additional cost to the Department or property owner.

521.04—Measurement and Payment

Mailbox posts will be measured and paid for at the contract unit price of each, complete-in-place, for the type specified. **Price bid** shall include furnishing and installing mailbox post and hardware; mounting the existing or new mailbox(s); removing the existing mailbox(s) and post(s); temporary re-location; setting new post; disposal of existing post(s); and for all materials, labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
Mailbox post (Type)	Each

Division VI
ROADSIDE DEVELOPMENT

SECTION 601—SELECTIVE TREE REMOVAL, TRIMMING, AND CLEANUP

601.01—Description

This work shall consist of selective cutting and disposing of trees, shrubs, and vegetation to improve sight distance, create open vistas, or improve the appearance and condition of trees. This shall be accomplished by removing and disposing of rubbish and fallen and undesirable trees and shrubs, selective pruning, and spraying stumps with an approved herbicide to prevent sprouting.

601.02—Materials

Herbicide shall conform to the requirements of Section 244.02(a).

601.03—Procedures

Trees and stumps shall be cut in such a manner that remaining stumps are not higher than 4 inches above the ground. Loose roots more than 1 inch in diameter and more than 1 foot in length shall be removed. Only those living trees and shrubs selected by the Engineer shall be removed. Trees to be removed shall be felled in a manner that will not damage the trees and shrubs to be preserved.

Debris shall be disposed of by burning or chipping or in accordance with the requirements of Section 106.04. Burning shall be performed in accordance with the requirements of Section 107.16. Fires shall be located and supervised so that they will not spread or damage vegetation. A mechanical chipper may be used, and the resulting chips spread thinly and uniformly within the immediate area or disposed of as directed by the Engineer.

- (a) **Treating Stumps:** Stumps of living trees and shrubs shall be coated with an herbicide solution within 48 hours after they are cut. The exposed surface of stumps and exposed live roots shall be saturated with herbicide to the point of runoff.
- (b) **Trimming:** Branches and limbs that affect sight distance or the open vista and dead or diseased branches and limbs more than 2 inches in diameter that will hinder the healthy normal growth of trees shall be removed as designated by the Engineer. Cuts shall be made flush at the collar of the supporting trunk or limb.

The Contractor's operations and equipment used to perform selective trimming shall not damage trees and shrubs that are to remain. Climbing spurs or spikes shall not be used. Damage to the bark, limbs, and roots of trees and shrubs that are to remain shall be repaired in a manner acceptable to the Engineer. Such repairs and the replacement in kind of those that cannot be satisfactorily repaired shall be at the Contractor's expense.

601.04—Measurement and Payment

Selective tree removal, trimming, and cleanup will be measured in acres of surface area computed to the nearest 1/10 acre and will be paid for at the contract unit price per acre.

Payment will be made under:

Pay Item	Pay Unit
Selective tree removal, trimming, and cleanup	Acre

SECTION 602—TOPSOIL

602.01—Description

This work shall consist of applying topsoil in accordance with the requirements of these specifications and in conformity with the depths and limits shown on the plans or as established by the Engineer.

602.02—Materials

- (a) **Class A topsoil** shall conform to the requirements of Section 244.02(b)1.
- (b) **Class B topsoil** shall conform to the requirements of Section 244.02(b)2.

602.03—Procedures

- (a) **Submittals:** When Class B topsoil is specified, the Contractor shall submit soil test reports to the Engineer for Class B topsoil in accordance with the requirements of Section 244.02(b).
- (b) **Preparing Areas to Receive Topsoil:** Unless otherwise designated on the plans or directed by the Engineer, areas designated to receive topsoil shall be graded, shaped, and then scarified or tilled by disking, harrowing, or other approved methods to a depth of approximately 2 inches. Topsoil shall be applied only when the subsoil is in a loose, friable condition. Subsoil on slopes that have been horizontally grooved in accordance with the plans shall not be loosened.
- (c) **Applying Topsoil:** The loose depth of topsoil shall be sufficient to allow the area to conform to the elevations shown on the plans after topsoil settles. After topsoil has been applied, large clods, hard lumps, and stones larger than 3 inches in diameter; brush; roots; stumps; litter; and foreign material shall be removed from the area. Where residential or commercial yards exist, the size of the large clods, hard lumps, and stones shall not exceed 3/4 inch in diameter. Such areas shall be hand raked to provide a smooth yard suitable for mowing by a yard mower. When the topsoiling operation is complete, the area shall be in a condition to receive seed, sod, or plants without further soil preparation. Areas shall be seeded within 7 calendar days after topsoiling is completed.

602.04—Measurement and Payment

Topsoil will be measured in acres of surface area computed to the nearest 0.1 acre and will be paid for at the contract unit price per acre. For smaller areas, and/or as identified on the plans, topsoil will be measured and paid for at the contract unit price per cubic yard. Such areas will be identified and la-

beled on the plans for cubic yards of soil to be applied. This price shall include soil testing and provision of test reports; preparing areas to receive topsoil; furnishing, loading, transporting, and applying topsoil; finishing areas; and restoring damaged areas.

Payment will be made under:

Pay Item	Pay Unit
Topsoil (Class and depth)	Acre
Topsoil (Class and depth)	Cubic yard

SECTION 603—SEEDING

603.01—Description

This work shall consist of furnishing and applying fertilizer, lime, mulch, and seed in the quantities specified for areas designated on the plans or selected by the Engineer.

603.02—Materials

- (a) **Seed** shall conform to the requirements of Section 244.02(c).
- (b) **Fertilizer** shall conform to the requirements of Section 244.02(d).
- (c) **Lime** shall conform to the requirements of Section 244.02(e).
- (d) **Mulch** shall conform to the requirements of Section 244.02(g).

603.03—Procedures

Unless otherwise specified, seeding operations shall be performed at the times specified in Sections 303.03(b) and 602.03(b). Seeding operations shall not be performed when the ground is frozen or when soil or weather conditions would prevent proper soil preparation and subsequent operations. When hydroseeding is performed, nozzles or sprays shall not be directed toward the ground in a manner that will cause erosion or runoff. The Contractor shall notify the Engineer at least 48 hours prior to beginning seeding operations.

- (a) **Applying Lime:** Lime shall be uniformly applied to areas to be seeded at the rate of 2 tons per acre. Any approved method may be used.
- (b) **Preparing Soil:** After lime is applied, areas to be seeded shall be prepared in accordance with the following: Slopes 3:1 or flatter shall be loosened to a depth of approximately 3 inches by disking, harrowing, or other approved methods. Loosening of soil on excavated slopes steeper than 3:1 will not be required except to eliminate hard or crusted surfaces. Shoulders and embankment slopes steeper than 3:1 shall be loosened to a depth of approximately 1 inch. Clods, loose stones, and other foreign material larger than 3 inches in any di-

mension shall be removed and disposed of in accordance with the requirements of Section 106.04 or as approved by the Engineer. Gullies, washes, and disturbed areas that develop subsequent to final dressing shall be repaired before they are seeded.

Topsoil, when specified, shall be applied in accordance with the requirements of Section 602.

- (c) **Applying Fertilizer:** When dry fertilizer is used, it shall be applied uniformly to the seeding areas at the time of seeding at the rate of 300 pounds of fertilizer per acre (approximately 45 pounds of nitrogen per acre or 1.0 pound of nitrogen per 1,000 square feet) or as directed by the Engineer. Slow release and slowly soluble fertilizer may be applied through a hydraulic seeder except for sulfur-coated urea (SCU). The method of application for fertilizer products will be approved by the Engineer prior to application of the fertilizer. When applied in liquid form or mixed with water, fertilizer shall provide the same value of nutrients per acre as specified for dry fertilizer. Fertilizer applied in liquid form shall be constantly agitated during application.
- (d) **Applying Seed:** Regular seeding shall consist of uniformly applying seed, fertilizer, and mulch on prepared areas.

Overseeding shall consist of applying seed and fertilizer on areas prepared as directed by the Engineer.

Where temporary seeding is employed as a means of soil stabilization it shall consist of applying seed, fertilizer, and mulch in accordance with the rates specified in the plans or in Section 603.03 to stabilize areas on which grading operations are anticipated to be suspended for durations greater than 15 days. Where temporary seeding is required or directed by the Engineer, the cost for removal of vegetation once grading operations resume shall be included in the price of seeding.

For hydroseeding, seed shall be put in the mixture slowly to result in a uniform mixture before application. Hydroseeding mixtures shall be constantly agitated from the time of mixing until application on the seed bed and used within 8 hours from the beginning of mixing.

If special seed is required in addition to the regular mixture, it will be furnished by the Department and shall be applied with the regular mixture at the Contractor's expense.

Leguminous seeds shall be inoculated or treated with approved cultures as specified by the manufacturer or directed by the Engineer before they are applied or mixed with other seeds to be applied. Seed shall be applied within 24 hours after treatment. When the hydroseeding method is used, leguminous seeds shall be treated with 5 times the amount of inoculant recommended by the manufacturer.

- (e) **Applying Mulch:** Mulch shall be applied in a separate application within 48 hours after completion of the seeding operation. When straw or hay mulch is used, it shall be applied on seeded areas at the rate of approximately 2 tons per acre. When wood cellulose fiber mulch is used, it shall be uniformly applied at the rate of approximately 1,500 pounds net dry weight per acre. Mulch will not be required on overseeded areas.

Straw and hay mulch shall be applied to a uniform thickness in such a manner that not more than 10 percent of the soil surface will be exposed at the conclusion of the mulching opera-

tions. Wet straw or wet hay shall not be used. Straw or hay mulch shall be anchored to the seeded surface by spraying with wood cellulose fiber mulch at the rate of 750 pounds per acre; spraying with an emulsified asphalt at the rate of at least 100 gallons per ton of mulch in a manner that will protect adjacent property and pedestrian traffic areas; disking or punching the mulch partially into the soil; using approved netting; or using other materials or methods approved by the Engineer. The Contractor may use more than one method on the same project.

603.04—Measurement and Payment

Lime will be measured in tons and will be paid for at the contract unit price per ton.

Fertilizer will be measured in tons and will be paid for at the contract unit price per ton. When a grade different than that specified in the Contract is used, the tonnage quantity will be adjusted to the grade specified.

Seed will be measured in pounds of seed used and will be paid for at the contract unit price per pound. When bags of seed are transferred from project to project, certified scales shall be used for weighing the seed. Open bags will not be accepted for use.

Prices for seed, fertilizer, and lime shall include preparing seed beds; furnishing and applying seed; furnishing and applying mulch; and maintaining seeded areas until final acceptance.

Overseeding will be paid for at the contract unit price per pound of seed. This price shall include preparing seedbeds and furnishing and applying seed and additional fertilizer.

Mulch will not be measured for separate payment. The cost thereof shall be included in the price for seed.

Payment will be made under:

Pay Item	Pay Unit
() seed	Pound
() overseeding	Pound
Fertilizer (Ratio)	Ton
Lime	Ton

SECTION 604—SODDING

604.01—Description

This work shall consist of preparing sod beds; furnishing and placing sod; and furnishing and applying lime, fertilizer, topsoil, and water at locations designated on the plans or by the Engineer.

604.02—Materials

- (a) **Sod** shall conform to the requirements of Section 244.02(h).
- (b) **Fertilizer** shall conform to the requirements of Section 244.02(d).
- (c) **Lime** shall conform to the requirements of Section 244.02(e).

604.03—Procedures

- (a) **Preparing Sod Beds:** Soil on which sod is to be placed shall be shaped to an even surface and graded to such an elevation that sod and adjacent surfaces will have a smooth contour.

Lime shall be uniformly applied to areas designated to receive sod at the rate of approximately 2 tons per acre.

Fertilizer shall be uniformly applied to areas designated to receive sod at the rate of 16 1/2 pounds of 15–30–15 fertilizer, or an equivalent quantity of 1–2–1 fertilizer, and 10 pounds of ureaformaldehyde per 1,000 square feet. Following application of lime and fertilizer, the soil shall be thoroughly cultivated to a depth of 2 to 3 inches and sprinkled with sufficient water to moisten the cultivated soil.

- (b) **Placing Sod:** Sod shall not be placed between June 1 and September 1 or at any time the ambient temperature is below 32 degrees F. Frozen sod shall not be placed, and sod shall not be placed on frozen soil. Sod shall be placed by hand, and joints shall tightly abut without overlapping. Open joints and gaps shall be plugged with sod that has been cut to the size and shape of the opening.

Sod shall be placed on sloping areas beginning at the bottom of the slope. Sod shall be placed in horizontal strips with the long edges of rectangular pads parallel to the contour. When practicable, horizontal joints shall be reasonably straight and vertical joints staggered. In areas where sod pads may be displaced by foot traffic during sodding operations, ladders or treaded planks shall be used.

Sod placed on slopes steeper than 2:1 shall be anchored in place with wood stakes driven flush with the top of the sod. Stakes shall be at least 8 inches in length with a cross-sectional area of approximately 1 square inch. The number and spacing of stakes shall be adequate to hold sod securely in place. Special attention shall be given to anchoring sod placed in drainage ditches, channels, and swales.

After sod has been placed, joints and gaps that were too small to be effectively plugged with sod shall be filled with loamy topsoil.

Sodded areas shall be watered thoroughly and rolled or tamped to press the root system of the sod into full contact with underlying soil.

Sodded areas shall be kept watered to maintain the life and growth of the sod until final acceptance.

604.04—Measurement and Payment

Sod will be measured in square yards of surface area, complete-in-place, and will be paid for at the contract unit price per square yard of surface area. This price shall include preparing sod beds; furnishing and applying lime, fertilizer, sod, and water; and maintaining sodded areas until final acceptance.

Payment will be made under:

Pay Item	Pay Unit
Sod	Square yard

SECTION 605—PLANTING**605.01—Description**

This work shall consist of furnishing and planting trees, shrubs, vines, and other plants of the kinds, sizes, and quantities specified on the plans or by the Engineer and maintaining and replacing plants as specified herein.

605.02—Materials

- (a) **Plants** shall conform to the requirements of Section 244.02(i).
- (b) **Drainage stone** shall conform to the requirements of Section 204.
- (c) **Composted Yard Waste** shall conform to the requirements of Section 244.02 (j).
- (d) **Geotextile Drainage Fabric** shall conform to the requirements of Section 245.
- (e) **Topsoil** shall conform to the requirements of Section 244.02(b)
- (f) **Horticultural Grade Perlite** shall conform to the requirements of Section 244.02(j).
- (g) **Tree Tubes** shall conform to the requirements of Section 244.02(j)
- (h) **Tree Anchors, Staking and Guying Materials** shall conform to the requirements of Section 244.02(j)
- (i) **All other Misc. Planting Materials** shall conform to the requirements of Section 244.02(j) and 244.02(k).

605.03—Procedures

- (a) **Documentation of Confirmed Order:** The Contractor shall submit documentation to the Engineer of a confirmed order of all plant materials 60 days in advance of the proposed planting operation. The documentation shall list the source(s) of supply, all species by common and botanical name, specific variety, and cultivar in the sizes reserved. When special requirements are listed on the planting summary sheet, such as “Specimen Quality,” or “Specimen Street Tree”, etc., the documentation shall certify that the species reserved meet those specific requirements. Once the Documentation of Confirmed Order is received, the Engineer reserves the right to require sample photographs of materials to be supplied. The Engineer also reserves the right to inspect and approve the selection of plant materials at the source of supply prior to delivery. In the event that specific materials are not available, the Contractor shall submit a request for substitutions in accordance with the requirements of (e) herein.
- (b) **Planting Season:** The Planting Season shall be from November 1, through March 31, unless otherwise identified on the plans. The Contractor shall notify the Engineer 48 hours prior to beginning work. All sources of supply, materials, construction schedule, and methods of construction shall be approved by the Engineer prior to beginning work on the project. Plants requiring either spring or fall planting only will be designated on the plans.
- (c) **Sources of Supply:** All plants shall be obtained from a nursery certified by a “Certificate of Registration” in accordance with The Virginia Department of Agriculture and Consumer Services (VDACS), or by a comparable agency responsible for nursery inspection and issuance of a “Certificate of Registration” from the State of origin. A copy of the certification shall accompany each separate delivery of plant materials to the project site, and shall be submitted to the Engineer.
- (d) **Inspecting and Identifying Plants:** Plants will be inspected and identified in accordance with the *Standardized Plant Names* prepared by the Editorial Committee of the American Joint Committee on Horticultural Nomenclature. The Engineer may inspect plants at any time and place. Plants will be inspected immediately prior to being planted. If plants are installed prior to inspection and found to be unsatisfactory, they shall be replaced with approved plants at the Contractor’s expense.
- (e) **Substitutions:** No change in the quantity, size, kind, or quality of plants from those specified will be permitted without the written approval of the Engineer. When requesting permission to substitute, the Contractor shall submit to the Engineer written evidence in accordance with the requirements of (a) herein that the specified plants are not available and shall suggest substitute plants that conform to the requirements of the Contract. The Contractor shall indicate the reduced cost, if any, that will accrue to the Department as a result of the substitution. The Engineer may delete plants from the Contract in lieu of approving substitutions.
- (f) **Layout:** Plant locations and outlines of bed areas to receive plants shall be staked or marked by the Contractor and will be inspected by the Engineer for approval prior to plant installation. The Contractor shall notify the Engineer a minimum of 48 hours prior to scheduling the inspection. Planting shall not be permitted until the Engineer has approved the staking layout. Unforeseen conditions such as the location of traffic signs, utilities and drainage items may necessitate adjustments in plant locations, and such adjustments will only be permitted when approved in writing by the Engineer.

- (g) **Delivery:** The Contractor shall notify the Engineer at least 48 hours in advance of the anticipated delivery date for plants. A legible copy of the invoice showing the kinds and sizes of plants in each shipment shall be submitted to the Engineer. A copy of the current Certificate of Nursery Inspection from the State of origin shall accompany each shipment of plants.
- (h) **Labeling:** Plant material delivered to the project shall be legibly identified with a waterproof label as to the genus, species, and size of the plants. When plants are in bales, bundles, boxes, or other containers, a legible label indicating the genus, species, size, and quantity of the plants shall be attached to each container. A minimum of 10 percent of each species in each shipment shall be so labeled. Failure to comply with this identification labeling will be cause for rejection.
- (i) **Transporting and Protecting:** Plants transported to the project in open vehicles shall be covered with suitable covers securely fastened to the body of the vehicle. Closed vehicles shall be adequately ventilated to prevent overheating plants. Plants shall be kept moist, fresh, and protected at all times.
- (j) **Storing:** When plants are to be stored, they shall be stored at a location approved by the Engineer. Plants stored for more than 30 days shall not be used unless approved by the Engineer. Unless the Engineer approves other methods of storage, bare-root plants that are not planted within 24 hours after delivery shall be heeled-in in a moist trench dug in the ground. Bundles shall be opened, and plants shall be separated and placed singly in the trench with the roots spread in a natural position. Roots of each layer of plants shall be immediately covered in a manner satisfactory to the Engineer with moist, pulverized soil; moist sawdust; or other approved material. Root-covering materials shall be kept moist at all times. Shade shall be provided as directed by the Engineer. At the discretion of the Engineer, balled material, container-grown material, and plants in plantable pots that are not planted within 48 hours of delivery shall have their root zone protected by wet sawdust or other approved material. Rejected plants shall be removed from the storage area within 24 hours of rejection or, with the written approval of the Engineer, may be marked with yellow paint or otherwise made readily identifiable. If rejected plants have not been removed or acceptably marked within 24 hours, the use of plants from the storage area will not be allowed until rejected plants have been removed or identified by marking.
- (k) **Planting:**
1. **Underground and Aboveground Conditions:** It shall be the responsibility of the Contractor to have marked, the location of all underground utilities with Ticket Information Exchange (TIE) / (Miss Utility) and all other applicable underground utility providers such as sewer and water service, and VDOT traffic signal cable prior to digging. The Contractor shall be responsible for locating and working around aboveground utilities. If underground obstructions or any other unforeseen subsurface or above surface conditions that could interfere with a utility or become detrimental to plant growth are encountered, the Engineer may require that plant pits be enlarged or relocated or that the plants be deleted from the contract.
 2. **Planting Trees or Shrubs on Slopes Steeper than 3:1:** Drainage requirements for trees or shrubs on slopes steeper than 3:1 will be determined by percolation tests, with no more than 3 tests per slope, as designated by the Engineer. Slopes for this test are determined from cut and fill slopes shown on the cross sections. Percolation testing shall consist of the following: The Contractor shall auger holes that are 12 inches in di-

imeter and 24 inches in depth. Three holes shall be distributed across the slopes vertically and horizontally. The Contractor shall fill the holes with water and allow them to drain. If soil is extremely dry, fill holes twice and allow to drain. Fill holes again and measure rate at which water percolates into the soil. Water in holes should recede at the rate of 2 inches per hour (minimum) or pit modification for improving drainage shall be required.

3. **Preparing Planting Pits for Trees and Shrubs:** Planting pits shall be excavated to meet the minimum requirements VDOT Road and Bridge Standards unless otherwise indicated on the plans by detailed drawings. Sides of pits that become plastered or glazed shall be scarified. Surplus excavation and unsuitable material shall be disposed of in accordance with the requirements of Section 106.04 or as otherwise approved in writing by the Engineer. Preparation of the planting medium (soil mix) shall utilize 3 parts of the original excavated soil from the digging operation thoroughly mixed with 1 part composted yard waste, except where linear or oversize planting pits are specified on the plans.

If the Contractor determines that the original excavated soil is not suitable for reusing with amendments for achieving an acceptable growing medium, the Contractor shall notify the Engineer. The Engineer shall make a determination as to the quality of the soil, and if found to be unacceptable; will direct the Contractor to use topsoil or composted yard waste for use in the soil mix. In such cases, the planting pit, and unsuitable soils surrounding the pit shall be removed as directed by the Engineer. The Engineer reserves the right to have the original soil tested prior to making a determination for replacement.

4. **Preparing Plant Beds:** Plant beds shall be prepared by the Contractor in accordance with the following:
 - a) Plant bed preparation shall only be required on slopes of 3:1 or flatter. Where grass and weeds are present, the Contractor shall treat the designated bed area(s) with a broad spectrum grass and weed killing herbicide at least two weeks prior to beginning bed preparation, or physically remove turf and weeds immediately before bed preparation. The entire area of the plant bed shall be cultivated to a depth of 4 inches by a rotary cultivator or other approved method. The Contractor shall then apply composted yard waste at a depth of three inches over the entire plant bed and re-till to form a homogenous soil medium. Soil shall be cultivated so that there are no clods larger than 2 inches in diameter.
 - b) Any remaining grass, sod, and weeds shall be removed from the bed. Rocks over 3 inches in diameter, clods, roots, and other objectionable material remaining on the surface shall be removed and disposed of in accordance with the requirements of Section 106.04 or as approved in writing by the Engineer. Individual planting pits shall not be dug until after the bed is prepared to the satisfaction of the Engineer.
 - c) Upon completion of planting, the bed shall be hand raked to an even surface and neatly edged with a "V" cut edge located a minimum of 12 inches from the root ball of plants along the outer edge of the bed. Mulch shall be applied to the entire bed area. On certain projects where mulched beds around large quantities of plant materials are used to control weed growth and are not intended as a prepared soil

medium, tilling and application of composted organic material throughout the plant bed shall be waived when beds are labeled on the plans as “Bed Preparation Not Required”.

5. **Linear Planting Pit:** Areas labeled on the plans and details as “Linear Planting Pit” shall be excavated to the horizontal and vertical dimensions indicated on the plans to receive soil mixture. Soil mixture shall consist of 1 part composted yard waste, and 1 part horticultural grade perlite, unless otherwise indicated in the contract documents, and shall include any necessary excavation required for installation of plant underdrain systems. Plant underdrain system(s), as applicable, shall be indicated on the plans, listed as a pay item and installed in accordance with plan details.

Soil mix for linear planting pits shall be installed in 6 inch lifts, lightly compacted by foot or other approved method, and moistened prior to proceeding with next lift. If settlement occurs prior to planting, additional soil mix shall be added at the direction of the Engineer. Prior to planting the Contractor shall till the linear planting pit to a depth of 4 inches, hand rake the area and adjust the grade adjacent to curb or sidewalk to receive 3 inches of mulch.

6. **Oversize Planting Pit:** shall be prepared in accordance with the plan details at locations shown on the plans. Backfill shall consist of one-half part native soil excavated from the plant pit, and one-half part composted yard waste. If native soil is determined by the Engineer to be unsuitable, 100 percent composted yard waste shall be used. If settlement occurs prior to planting, additional soil mix shall be added at the direction of the Engineer. After planting the planting pit shall be neatly edged except when the planting pit falls within a larger bed area.
7. **Installing Trees and Shrubs:** Balled and burlapped and containerized plant materials shall be installed in plant pits in accordance with the requirements of the VDOT Road and Bridge Standards, unless otherwise indicated on the plans. Bare roots of plants shall be spread out in a natural position. Broken or bruised roots shall be pruned. After positioning plants in the planting pit and prior to backfilling, root ball wrapping materials, except metal root ball cages shall be cut and dropped to the bottom of the pit. Root ball wrapping materials shall not be removed from under the root ball. Metal root ball cages shall be cut and removed to a minimum of 6 inches below finished grade. Wrapping materials within root ball cages shall be cut or unwrapped to the same elevation as the cage. All other wrapping materials such as tags, twine and colored marking ribbon shall be removed from the plant unless otherwise directed by the Engineer. The soil mixture shall then be filled in around roots and lightly tamped. Light tamping around root balls shall be performed using a method approved by the Engineer. Foot tamping will be permitted in the bottom of pits before plants are installed, around root balls when there is ample room to accommodate the foot without damage to the ball, and in the planting of bare-root plants after roots have been covered with the soil.

Backfill material in pits shall be saturated with water. The amount of water applied and method of application shall be approved by the Engineer. Failure to water properly at the time each plant is installed will be cause for rejection of the plant. Frozen backfill material shall not be used.

Potted plants shall not be removed from their container until immediately before planting. Containers shall be removed by approved methods that will not damage roots or

loosen soil balls. The sides of containerized materials shall be scarified prior to planting.

When planted, watered, and fully settled, plants shall be vertical and shall stand at a height flush with the height of which they were growing.

8. **Handling Plants during Planting:** Roots of bare-root plants shall be kept covered with moist burlap or other approved material prior to planting. Forest tree seedlings and forest tree transplants shall be carried in a container filled with sufficient mud to puddle roots. When seedling roots have been coated with a protective material, the seedlings shall be protected in accordance with the U.S. Forest Service's recommendations relative to treatment of seedling roots while seedlings are being planted. Plants will be rejected if their roots are exposed to drying conditions at any time.
- (l) **Forming Water Rings and Saucers:** Immediately after the installation of each plant, a saucer shall be formed around the plant pit. Soil used to form the saucer shall be compacted by tamping to prevent runoff of water from the pit. Saucers shall measure 4 to 6 inches in width, and 2 to 3 inches in height after tamping. Saucers will not be required for forest tree seedlings, or forest tree transplants. Water rings and saucers shall be formed on the wetland trees and shrubs planted on slopes and upland areas adjacent to the wetland.
 - (m) **Applying Mulch:** Mulch shall be applied uniformly to a 3-inch depth over the entire area of the plant pit or plant bed within 48 hours after completion of planting. Re-mulching at the terminus of the establishment period shall be applied at a depth of 1-1/2 inches. Mulch shall be anchored in a manner satisfactory to the Engineer. Mulch shall not be required for wetland trees and shrubs, or upland forest tree seedlings. Mulch shall be applied to wetland trees and shrubs on slopes and upland areas adjacent to the wetland.
 - (n) **Staking, Guying, Anchoring:** Each plant shall be staked and guyed or secured with below ground tree anchors immediately following planting, unless otherwise indicated in the Planting Plan Summary and General Notes. Below ground tree anchors shall be used when specified on detailed drawings in the plans. Staking and guying shall be required for wetland trees and shrubs on slopes and upland areas adjacent to the wetland.
 - (o) **Pruning:** Plants that have been freshly pruned before delivery will be rejected. If necessary, plants shall be pruned either immediately before or within 48 hours after they are planted. Pruning of trees and shrubs to be planted on projects shall consist of removing dead, diseased, broken or other branches deemed injurious to the health of the plant, and for removal of sprouts and sucker growth. Care shall be taken to preserve the natural character of the plant. Pruning shall be performed with tools and equipment in excellent working condition that are specifically designed for the appropriate work. All pruning shall be performed in accordance with the current American National Standards Institute (ANSI A300) and as directed by the Engineer. All debris removal including disposal from the pruning operation shall be the responsibility of the Contractor.
 - (p) **Pit Drains:** Pit drains or plant underdrain systems shall be installed as shown on the plans.
 - (q) **Tree Tubes:** This work shall consist of installing tree tubes on all seedling trees in accordance with the manufacturer's recommendations, the plans and product specifications.

605.04—Care of Plants

Plant care shall begin immediately after each plant is satisfactorily installed and shall continue until final acceptance. Care shall include but not be limited to replacing displaced mulch, repairing and re-shaping water rings or saucers, maintaining stakes and guys as originally installed, watering when needed or as directed by the Engineer, and performing any other work required to keep plants in a healthy condition. Dead, defective, or rejected plants shall be immediately removed and replaced in accordance with the requirements of Section 605.05(b)4.

605.05—Establishment Period

- (a) **Beginning of Establishment Period:** The establishment period shall begin on a date following completion of the planting (spring or fall), when the Contractor receives written confirmation from the Engineer, that all work has been completed in accordance with the requirements of this Section and the plans, and that all plants are living, healthy and in a viable growing condition as determined by the Engineer. Plants that are replaced in order to meet these initial specifications are not considered as “plant replacements.”
- (b) **Establishment Period:** The establishment period shall continue through a minimum of one growing season, and shall terminate on the date determined in writing by the Engineer. During the establishment period, the Contractor shall do all work necessary to keep the plants in a healthy growing condition, including, but not limited to the following:
 - 1. **Watering:** The Contractor shall prepare and submit to the Engineer a schedule for watering in accordance with the frequency listed on the project summary sheet. However, the Contractor shall be responsible for watering as frequently as is necessary to maintain an adequate supply of moisture within the root zone of all plantings at all times or if there is less than 1 inch of rainfall in a seven day period during the months of April through September. Water shall not be applied at a force that will displace soil or mulch. Quantities and frequency of watering shown on the plans are for minimum estimating purposes only.
 - a) The Engineer may require the use of watering needles or other approved methods to prevent displacement of soil, mulch and runoff of water. The Engineer may make periodic inspections to ascertain the adequacy of the Contractor’s watering and the moisture content of the soil.
 - b) The quantity of water supplied shall not be in excess of that normally required to ensure optimum growing conditions. Watering shall not commence until methods and equipment have been approved by the Engineer. The Engineer may require or suspend watering at any time.
 - 2. **Notification and Scheduling:** When notified by the Engineer that watering is required, the Contractor shall begin watering within 48 hours with sufficient labor and equipment and shall continue to water daily where and as directed, without delays or interruptions, to ensure that the root zone does not become dry at any time. In the event the Contractor fails to begin watering operations within 48 hours after notification, the Engineer may proceed with adequate forces, equipment, and materials to perform the watering operations and the entire cost of the watering operations will be deducted from monies due the Contractor.

3. **All establishment period maintenance work**, except watering, shall begin within 7 working days after the Engineer notifies the Contractor that the establishment period has begun.
4. **Plant Replacements:** Between the beginning and ending dates of the establishment period, plants that are dead, defective, or otherwise not in a healthy growing condition as determined by the Engineer shall be removed immediately at the Contractor's expense. Plant replacements shall be made once in the spring if required (Between March 1 and March 31), and once in the fall if required (Between November 1 and December 31), as necessary to replace dead or defective plant materials as directed by the Engineer. For each plant replaced, the first replacement, if required, shall be at the Contractor's expense. The second replacement, if required, will be paid for at 35 percent of the original contract unit price per each plant replaced.
5. **Stakes, and Guys, and/or Below Ground Tree Anchors** shall be repaired or replaced immediately as needed. Stakes and Guys shall be removed when no longer required as directed by the Engineer. Tree anchors shall remain in place.
6. **Eroded Saucer Rings** shall be repaired or replaced as needed and/or as directed by the Engineer.
7. **Mulch** shall be redressed as needed and/or as directed by the Engineer throughout the establishment period.
8. **Re-mulching:** When established as a separate pay item, remulching shall be reapplied to all individual plants and plant beds prior to the terminus of the establishment period at a rate of approximately 1 1/2 inch depth, uniformly over all individual plant pits and plant beds, and/or as directed by the Engineer.
9. **Vegetation Control** shall consist of the control and/or removal of weeds, grass and root growth from plant beds and mulched areas around individual plants. Such weeding shall be performed once in the month of May, June, July, August, and September for a total of five weeding operations over the duration of the establishment period. The Contractor shall submit a schedule for vegetation control for approval by the Engineer prior to the Contractor beginning vegetative control operations.
 - a) Removal of weeds, grass and root growth may be completed by hand or through the application of "pre-emergent" and "post emergent" herbicides as approved by the Engineer. All herbicide applications shall be performed by certified pesticide applicators in accordance with the requirements of Section 601. Additional weeding may be performed when requested by the Engineer and with written agreement from both parties. The Engineer also reserves the right to delete individual weeding cycles at no cost to the Department when necessary. The Contractor shall be responsible for replacing plants that are damaged or that die due to the application of herbicide treatments.
 - b) When herbicides are used for post emergent weed control, the weeds shall be cut to a height of 6 inches or as recommended by the manufacturer if necessary, prior to applying the herbicide. The Engineer reserves the right to change the frequency or delete specific areas scheduled for weed control. Other pesticides, adjuvants and plant growth regulators may be used when approved by the Engineer.

- c) Turf maintenance which includes grass and other vegetation around individual plant pits, between groups of plant pits that are 15 feet on center or less, and around the perimeter of plant beds shall be cut to a height of approximately 4 inches. For each individual plant pit, group of plant pits, and plant beds, a perimeter extending 5 feet in width shall be maintained around the outermost plant pits and edge of beds where grass and other vegetation is present, and where such areas exist within the right-of-way or construction easement. Mowing shall be performed once in each month of May through September. Additional mowing may be performed when requested by the Engineer. The Engineer reserves the right to delete individual mowing cycles when deemed necessary by the Engineer.
10. **Additional Work**, including pruning of dead, broken or diseased branches, and seasonal spraying with approved insecticides and fungicides, shall be performed to ensure plant survival as approved or directed by the Engineer.
- (c) **Termination of Establishment Period:** Any dead, missing, or defective plants shall be replaced as directed by the Engineer prior to termination of the establishment period. The Engineer shall be notified within 48 hours prior to beginning the replacement work.

The establishment period shall end on a date established by the Engineer, when the Contractor receives written notification from the Engineer that confirms all the requirements of (b) herein have been satisfactorily completed.

605.06—Guarantee

The Contractor's performance bond, furnished in accordance with the requirements of Section 103.05, shall provide for necessary maintenance during the establishment period and replacements in kind, or with a substitute acceptable to the Engineer, for plants that are not in a healthy growing condition or that have died back to the crown or beyond the normal pruning limit.

605.07—Measurement and Payment

Plants will be measured by an actual count of living plants in a healthy growing condition and will be paid for at the contract unit price per each. Plants that the Engineer deleted from the Contract will not be measured for payment. This price shall include furnishing and delivering plants and miscellaneous planting materials; preparing planting pits, except when established as a separate pay item, forming saucers; installing plant materials; watering, except during establishment period, applying fertilizer; back filling with approved soil mixture; staking; guying; anchoring; pruning; applying mulch, except to areas designated on the plans as plant beds, replacing dead or damaged plants; repairing, replacing and removing stakes and guys when no longer needed; and maintaining plants in a healthy growing condition until final acceptance.

Trees or shrubs planted on a slope steeper than 3:1 with pit modification as indicated in the Department's Road and Bridge Standards Section 1201.06 will be paid for at 125 percent of the price bid. Such price shall also include the cost of pit modification, stone and geotextile filter fabric. Percolation tests shall be included in the price bid for plants.

Replacements for plants lost during the establishment period because of theft, damage, or destruction caused by persons or equipment belonging to persons or organizations other than those engaged in

performing the work or during delivery of the plants, or plants lost due to damage from animals either wild or domestic, will be paid for at the rate of 35 percent the contract unit price per each. If vandalism or vehicle damage is determined by the Engineer to be the cause the rate will be 50 percent the contract unit price per each. This price shall include all costs associated with furnishing and installing the replacement. Replacements for plants that die due to other reasons shall be replaced and paid for in accordance with the requirements of Section 605.05(b)4.

Bed Preparation will be measured and paid for in units of 100 square feet of surface area. This price shall include herbicide spraying of areas to be prepared for planting or physically removing turf and weeds, restoring areas to original grade with topsoil (as applicable) as directed by the Engineer, tilling soil, furnishing, delivering, and applying composed yard waste at the specified depth, tilling in composted yard waste, hand raking, neatly edging bed, and all incidentals necessary to prepare a healthy growing medium for planting.

Pit drains when detailed and established as a separate pay item on the plans will be measured and paid for in units of each, complete-in-place, which price shall include drainage stone, pipe, pipe grate, prefabricated drainage core, drainage/aeration cloth, and geotextile drainage fabric as designated on the plans.

Linear Planting Pit will be measured and paid for in units of cubic yards of excavated material required to achieve the horizontal and vertical dimensions indicated on the plans to receive soil mixture, including furnishing, delivering and storage of soil mixture materials to be used, and disposal of surplus excavated materials. Such price shall also include the cost of mixing and installing all components of the soil mix (horticultural grade perlite and composted yard waste), bed preparation, hand raking and adjusting surface to receive mulch, and furnishing and installing underdrain system(s) if indicated on the plans, including drainage stone, drainage/aeration cloth, prefabricated drainage core, geotextile drainage fabric, pipe, and pipe grate in accordance with the plans and detailed drawings, and all necessary incidentals complete in place.

Oversize Planting Pit will be measured and paid for in units of each, which price bid shall include excavation and disposal of unsuitable material, provision, and installation of pit drain materials if shown as part of the plan details, installation of approved backfill material and mixing with composted yard waste.

Mulching will be measured in units of 100 square feet of surface area. Mulch for plant beds at the time of initial installation will be paid for at the contract unit price per 100 square feet. This price shall include furnishing, delivering, and applying mulch. No separate payment will be made for initial application or maintenance of mulch around plants that are not in continuous mulched plant beds. The cost thereof shall be included in the price for the plant.

Re-mulching, when established as a separate pay item, will be measured and paid for in cubic yards. This price shall include furnishing, delivering, and applying mulch to plant beds, and to plants in individual saucer rings prior to the terminus of the establishment period. Remulching does not include regular maintenance of individually mulched plants or plant beds for the duration of the establishment period.

Watering during the establishment period will be measured in units of 1000 gallons, and will be paid for at the contract unit price per unit, applied at the rates designated on the plans. This price shall include furnishing, delivering, and applying water and performing all other work in connection therewith and incidental thereto. No payment will be made for watering at the time of original planting or

during the installation period until from plant installation until the start of the establishment period or whenever replacements are planted.

Vegetation Control will be measured and paid for on a unit basis. Compensation for weeding (removal of weeds, grass, and root growth) and turf maintenance shall be made on a Unit basis consisting of each complete project weeding and turf maintenance operation accomplished by the Contractor, including the removal and disposal of unwanted vegetation, application of pesticides, the performance of mowing around and between individual plants, and as reviewed and approved by the Engineer.

Tree Tubes will be measured and paid for at the contract unit price per each which shall include furnishing and installing the tube, including all incidentals necessary to complete the work. This price shall also include the removal and disposal of the tree tube at the end of the establishment period.

Payment will be made under:

Pay Item	Pay Unit
(Name of) Plant (Size)	Each
Bed Preparation	Unit (100 square feet)
Pit Drain	Each
Linear Planting Pit	Cubic Yard
Oversize Planting Pit	Each
Mulching	Unit (100 square feet)
Re-mulching	Cubic Yard
Watering	Unit (1,000 gallons)
Vegetation Control	Unit
Tree Tube	Each

SECTION 606—SOIL RETENTION COVERINGS

606.01—Description

This work shall consist of furnishing and placing protective coverings for soil retention, including seed, fertilizer, lime, topsoil, and water, in accordance with the requirements of these specifications and in conformity to the dimensions, lines, and grades shown on the plans or as established by the Engineer.

606.02—Materials

Materials for protective coverings and soil stabilization mats shall conform to the requirements of Section 244.02(k).

Soil Stabilization mats used for culvert outlet protection shall be Standard EC-3 Type B conforming to the requirements of Section 244.02(k).

606.03—Procedures

- (a) **Preparing Areas:** Two inches of topsoil shall be applied to the area to be covered. Drainage channels shall be shaped in accordance with the cross section shown on the plans and shall be rolled or tamped to compact soil in place before final shaping.

During shaping operations, a seedbed approximately 3/4 inch in depth shall be provided.

Stones, roots, and other objects that will prevent protective covering from making close contact with the seedbed shall be removed before covering is installed.

- (b) **Applying Seed:** Seed shall be applied in accordance with the requirements of Section 603 except that mulch will not be required. Seed, fertilizer, and lime shall be applied prior to installation of protective coverings.

Seeded areas adjacent to the channel or ditch that are disturbed during installation of covering shall be uniformly reshaped, reseeded, and mulched at the Contractor's expense.

- (c) **Installing Soil Retention Coverings:** Coverings shall be installed in accordance with the standard drawings and manufacturer's recommendations.
- (d) **Watering:** After coverings are installed, seeded areas shall be watered sufficiently to saturate the seedbed. Water shall be applied in a spray, and no additional watering will be required.

606.04—Measurement and Payment

Protective coverings and soil stabilization mats will be measured in square yards of area covered, complete-in-place, in accordance with the nominal plan dimensions and will be paid for at the contract unit price per square yard. Overlaps, overwidths, and cut slots will not be measured for separate payment. This price shall include furnishing, installing, and stapling soil retention coverings; smoothing and shaping ditch channels and waterways; preparing seed beds; and furnishing and applying topsoil, lime, seed, fertilizer, and water.

Payment will be made under:

Pay Item	Pay Unit
Protective covering (Standard)	Square yard
Soil stabilization mat (Standard and type)	Square yard

SECTION 607—HERBICIDE SPRAYING**607.01—Description**

This work shall consist of applying an approved herbicide for the control of weeds in turfed areas as indicated on the plans or as designated by the Engineer.

607.02—Materials

Herbicide shall conform to the requirements of Section 244.02(a).

607.03—Procedures

Herbicide shall be applied in accordance with the manufacturer's recommendations. Herbicide shall not be applied when the ambient temperature is above 85 degrees F or below 60 degrees F. The spray pressure shall be at least 20 but not more than 30 pounds per square inch. Spraying shall not be performed when the vegetation is wet, when it appears that rain is imminent within 6 hours, or when the wind is blowing enough to scatter paper or trash.

607.04—Measurement and Payment

Herbicide spraying will be measured in units of 1,000 gallons of mixture and will be paid for at the contract unit price per 1,000 gallons. This price shall include furnishing and applying herbicide.

Payment will be made under:

Pay Item	Pay Unit
Herbicide spraying	Unit (1,000 gallons)

SECTION 608—MOWING**608.01—Description**

This work shall consist of mowing designated areas to a height of not less than 4 inches when and as directed by the Engineer until final acceptance.

608.02—Equipment

Equipment used for mowing operations shall be mechanical with a cutting width of at least 5 feet.

608.03—Measurement and Payment

Mowing, when a pay item, will be measured in hours of operation and will be paid for at the contract unit price per hour. This price shall include equipment, operators, fuel, and lubricants.

Payment will be made under:

Pay Item	Pay Unit
Mowing	Hour

SECTION 609—TREE WELLS AND TREE WALLS

609.01—Description

This work shall consist of constructing wells and walls to protect the root system of trees, shrubs, or other woody plants at the locations shown on the plans or as designated by the Engineer.

609.02—Materials

Aggregate shall conform to the requirements of Section 203.

PVC pipe shall conform to the requirements of Section 232(g).

Geotextile fabric shall conform to the requirements of Section 245.

Rubble for masonry shall conform to the requirements of Section 204.

609.03—Procedures

Excavation incidental to and necessary for constructing tree wells and tree walls shall be conducted in a manner that will not damage the root system. Ends and damaged sections of roots shall be cleanly cut. Roots with a diameter of more than 3 inches shall not be cut.

Before any earth fill that will exceed 12 inches in thickness is spread over the feeding root system of trees or shrubs to be protected by tree wells, an aeration layer of coarse gravel or stone ranging from 1/2 to 5 inches in size shall be spread over the entire area for a depth of at least 6 inches or at the rate of 3 inches for every 12 inches of earth fill where such fills will be more than 2 feet in depth. The layer of aggregate shall be covered with sufficient fine screenings to choke the top of the porous fill. Aggregate shall not be placed inside the tree well.

609.04—Measurement and Payment

Tree wells and tree walls will be measured in cubic yards of masonry, complete-in-place, and will be paid for at the contract unit price per cubic yard of masonry. This price shall include excavation; drainpipe; and backfill, including aggregate.

Payment will be made under:

Pay Item	Pay Unit
Tree well (Standard)	Cubic yard
Tree wall (Standard)	Cubic yard

SECTION 610—GABIONS

610.01—Description

This work shall consist of furnishing and installing gabions in accordance with these specifications and in conformity to the lines, dimensions, and grades shown on the plans or as established by the Engineer.

610.02—Materials

- (a) **Gabions** shall have a uniform horizontal width of at least 36 inches. Their dimensions shall be within ± 3 percent of the manufacturer's stated sizes.
- (b) **Wire mesh** shall conform to the requirements of Section 223.02(a).
- (c) **Selvedge (or perimeter) wire** shall be at least 0.148 inch in diameter (9 gage) and shall conform to the requirements of Section 223.02(a) for wire mesh.
- (d) **Tie and connection wire** shall conform to the requirements for the wire used in the mesh except that it shall be not more than two gages smaller.
- (e) **Gabion stone** shall conform to the requirements of Section 204.

610.03—Procedures

Gabions shall be fabricated in such a manner that the sides, ends, lid, and diaphragms can be assembled at the construction site into rectangular baskets. Gabions shall be of single-unit construction whereby the base, lid, ends, and sides are woven into a single unit or whereby one edge of these units is connected to the base section of the gabion. The strength and flexibility at the point of connection shall be at least equal to those of the mesh.

If the length of the gabion exceeds its horizontal width, the gabion shall be equally divided into cells by diaphragms of the same mesh and gage as the body of the gabion. The length of each cell shall not exceed its width. The gabion shall be furnished with the necessary diaphragms secured in the proper position on the base so that no additional tying at the junction will be necessary.

Perimeter edges of the mesh forming the gabion shall be securely clip bound or selvedged in such a manner that the joints formed by tying the selvedges will have at least the same strength as the body of the mesh.

Tie and connection wire shall be supplied in sufficient quantity to fasten securely all edges of the gabion and diaphragms. At least two cross-connecting wires shall be in each cell whose height is one-third or one-half the width of the gabion. At least four cross-connecting wires shall be in each cell whose height equals the width of the gabion. The wire shall be secured through two open loops of the cage.

610.03

Excavating and backfilling for gabions shall be performed in accordance with the requirements of Section 303. Gabions shall be placed on a smooth foundation, and the final line and grade shall be approved by the Engineer.

Each gabion unit shall be assembled by binding the vertical edges with wire ties at approximately 6-inch intervals or by stitching a continuous piece of connecting wire around the vertical edges with a coil approximately every 4 inches. Wire ties or connecting wire shall be used to join units in the same manner as described for assembling. Internal tie wires shall be uniformly spaced and securely fastened in each cell of the structure.

A standard fence stretcher, chain fall, or iron rod may be used to stretch wire baskets and hold the alignment.

Gabions shall be filled with stone in a manner that will ensure alignment, ensure a minimum of voids, and avoid bulges. Rock and connection wires shall be alternately placed until the gabion is filled. After the gabion is filled, the lid shall be bent over until it meets the sides and edges of the gabion. The lid shall be secured to the sides, ends, and diaphragms with wire ties or connecting wire in the manner described for assembling.

610.04—Measurement and Payment

Gabions will be measured in cubic yards, complete-in-place, and will be paid for at the contract unit price per cubic yard. This price shall include furnishing and installing gabions; excavating; backfilling with suitable material; compacting; and disposing of surplus or unsuitable material.

Minor structure excavation for gabions, when specified on the plans, will be measured and paid for in accordance with the requirements of Section 303.

Payment will be made under:

Pay Item	Pay Unit
Gabion	Cubic yard

Division VII
TRAFFIC CONTROL DEVICES

SECTION 700—GENERAL**700.01—Description**

These specifications cover general construction items, methods, and procedures common to traffic control devices. Installation of materials shall be accomplished in accordance with the manufacturer's instructions except when otherwise indicated.

700.02—Materials

- (a) **Concrete** shall be Class A3 conforming to the requirements of Section 217.
- (b) **Reinforcing steel** shall conform to the requirements of Section 223.
- (c) **Paint** shall conform to the requirements of Section 231 and shall be applied in accordance with the requirements of Section 411 except on nonferrous materials, where it shall be applied in accordance with the requirements of the manufacturer's recommendations.
- (d) **Galvanizing** shall conform to the requirements of Section 233.
- (e) **Electrical items** shall conform to the requirements of Section 238.
- (f) **Wood for posts and poles** shall conform to the requirements of Section 236 and shall be treated in accordance with the requirements of Section 236. Wood items shall be cut prior to treatment.
- (g) **Steel** for fabricated items shall conform to the requirements of Section 226 and shall be fabricated, welded, and inspected in accordance with the requirements of Section 407.
- (h) **Aluminum** for fabricated items shall conform to the requirements of Section 229 and shall be fabricated, welded, and inspected in accordance with the requirements of Section 407.
- (i) **Poles, posts, and overhead and bridge-mounted sign structures** shall conform to the following:
 - 1. **Conventional and offset lighting poles** shall be steel or aluminum.
 - 2. **Overhead and bridge-mounted sign structures, signal poles (mast arm and strain), and high-mast lighting poles** shall be steel.
 - 3. **Pedestal poles** with a nominal diameter of more than 2 inches shall be steel or aluminum. Pedestal poles 2 inches and less in nominal diameter shall conform to the requirements of Section 238 for metal conduit.
 - 4. **Sign posts** shall be wood or steel.

Lighting, signal, and pedestal poles; sign posts; and overhead and bridge-mounted sign structures not designed to support variable message signs shall conform to the requirements

of the 1994 Edition of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*.

Overhead and bridge-mounted sign structures, including "butterfly" structures, designed to support variable message signs shall conform to the requirements of the 2001 Edition of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* and the following clarifications:

- Basic wind speed shall be used in the designs. The alternate method for wind pressures provided in Appendix C shall not be used.
- When the installation location of the structures lies between isotachs, the basic wind speed shall be determined by using the higher adjacent isotach.
- Any optional design parameters indicated in the AASHTO specification that are "allowed when acceptable to the owner" shall not be used for the designs.

Steel poles, posts, and overhead and bridge-mounted sign structures shall be hot-dip galvanized after fabrication. Except when shop painting is required, steel poles and posts shall be given one shop coat of primer and two field coats of paint and the galvanization finish of overhead and bridge-mounted sign structures shall be field treated for paint retention and two coats of paint applied.

Signal, lighting, and pedestal poles shall be of a one-piece or sectional single unit, tubular form, and shall be round or multisided. Multisided poles shall have at least eight sides. Pole shafts and arms shall have a removable cap fastened by at least three screws.

Mast arms shall not deflect below the horizontal plane or exceed a rise of 3 percent of the arm length after loads are applied. Mast arm poles shall include an arm attachment flange plate continuously welded to the gusset and side plates. The gusset and side plates shall be continuously welded to the pole and each other. The flange shall be fabricated with four studs permanently attached for receiving nuts (attaching arm). The flange plate and pole shall have a 2 1/2-inch wiring hole with a grommet centered in the pattern.

Strain poles shall not exceed a dead load deflection of 3 percent of the distance between the base of pole and point of dead load attachment. The minimum bottom diameter of strain poles shall be 11 inches.

Signal poles shall have a steel "J" hook located inside the poles for wire suspension within 5 inches of the top.

Lighting, signal poles, and overhead structures shall have a grounding lug welded to the inside of the pole or structure easily accessible from the hand hole. The grounding lug shall be designed to secure the grounding electrode conductor and equipment-grounding conductor by inserting the conductor under a setscrew type of lug.

Signal poles, high-mast lighting poles, and overhead sign structures, including butterfly structures, shall have a minimum of six anchor bolts, each having a minimum diameter of 1 1/2 inch. The maximum space between the bottom of the base plate and the top of the foundation shall be no greater than the diameter of the anchor bolt plus 1 inch.

No grout will be permitted between the base plate and the top of the foundation of overhead structures, mast arm, lighting, and signal poles. No lock nuts or split washers will be allowed with the anchor bolts.

- (j) Anchor bolts shall be steel, conforming to the requirements of Section 226.02(c)2. The portion of anchor bolts beginning 4 inches below the top of the foundation and extending above the foundation shall be galvanized except when stainless steel is used.

Anchor bolts used with signal poles, high-mast lighting poles, and overhead sign structures, including butterfly structures, shall conform to the requirements of Section 517 of the 2001 Edition of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*.

- (k) **Breakaway support systems** shall conform to the requirements of the 1994 Edition of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*.

1. **Breakaway couplers and skirt covers** shall be aluminum. Threaded studs, nuts, and washers shall be stainless steel or galvanized steel.
2. **Fragible bases** shall be aluminum.
3. **Slip bases** shall be galvanized steel or other approved noncorrosive metal.

- (l) **Miscellaneous hardware** shall be brass, bronze, stainless steel, or galvanized steel.

700.03—Working Drawings

The Contractor shall submit working drawings to the Engineer, including design calculations and catalog cuts, in accordance with the requirements of Section 105.10 except that each copy shall be submitted with the manufacturer's name and address clearly noted. Submitted data for the following aluminum lighting poles shall also specifically address how fatigue was considered in the design of the poles:

1. Conventional aluminum lighting poles with a height of 40 feet or greater.
2. Offset aluminum lighting poles with a height of 20 feet or greater.
3. Other aluminum lighting poles with a height greater than 20 feet and a pole-top-mounted luminaire.
4. All aluminum lighting poles mounted on bridges

Fatigue may be addressed through the use of vibration dampening devices or through other means as determined by the manufacturer.

In lieu of working drawings and catalog cuts, the Contractor may submit a letter indicating the brands, types, and models of equipment along with the approval numbers and contract item numbers. The Contractor shall include the words "Testing Required" with the approval numbers when materials testing is required for the equipment. The approval numbers shall be taken from the Department's

Preapproved Traffic Control Device List. Any equipment on the list for which approval has been rescinded will not be allowed for use if the rescinded date is earlier than the receipt of bids for the project. Inclusion of equipment on the list does not ensure acceptance if contract requirements prohibit use of the equipment. The Contractor shall ensure that the equipment as furnished conforms to the requirements of the Department.

700.04—Procedures

- (a) **Grounding Electrodes:** Grounding electrodes (rods) shall be installed in accordance with the requirements of the NEC or by other methods approved by the Engineer. Grounding electrodes shall be installed using a hydraulic/pneumatic/electric hammer drill driving device with an electrode drive bit to minimize damage to the electrode tip. The electrode drive bit shall be designed for 3/4-inch electrodes. Grounding electrodes shall include a grounding electrode conductor and grounding electrode clamp.

1. **Electrical service grounding electrode installations:** The following procedures apply only to installing electrical service grounding electrodes:

- Grounding electrodes and grounding electrode conductors shall be installed in the presence of the Engineer at a date and time mutually agreed upon.
- Grounding electrode and grounding electrode conductors shall be connected using exothermic welds. Exothermic welds shall be designed for the size conductor and grounding electrodes and shall be installed in accordance with the manufacturer's instructions. Grounding electrode conductors and grounding electrodes shall be cleaned to remove oxidation and any other foreign material from the surface before performing the exothermic welds.
- Primary grounding electrodes shall not have a resistance to ground of more than 25 ohms. A 10-foot section of grounding electrode shall have a minimum of an 8-foot contact with soil. Grounding electrodes shall be spaced a minimum of 10 feet between all electrodes.
- Primary grounding electrodes shall be installed vertically to a depth of 40 feet or until refusal. If the vertical grounding electrode cannot be installed to a minimum of an 8-foot contact with soil, the Contractor shall install a grounding electrode at an angle of no more than 45 degrees to a depth of 40 feet or until refusal. If refusal occurs prior to installing the electrode to a minimum of an 8-foot contact with soil, the Contractor shall remove the electrode or cut it off 6 inches below grade and abandon it.
- Primary grounding electrodes complying with these requirements shall be augmented with an additional grounding electrode and connected in parallel to the primary grounding electrode to form a system. The augmented electrode shall be a single electrode driven to a depth of 4 inches below the finished grade. If refusal occurs prior to installing the electrode to a minimum of an 8-foot contact with soil, Contractor shall remove the electrode or cut it off 6 inches below grade and abandon it.

- Grounding electrodes shall be coupled at each section with couplers or exothermic welded splices. The grounding electrode conductor shall be installed to a depth of 18 inches below grade when connecting the primary electrode and augmented grounding electrodes.
- The Contractor shall install a JB-2C junction box at the primary grounding electrode location for access to the electrode for connection and testing. Grounding electrode conductors shall be installed under the bottom flange of the JB-2C. The grounding electrode shall be centered in the bottom of the JB-2C with a minimum of 6 inches exposed. The JB-2C cover shall have the letters “VDOT ELEC” cast in the depression on the top.

The Contractor shall notify the Engineer of those location(s) where primary grounding electrodes do not conform to the following:

- Resistance does not measure 25 ohms or less.
- Grounding electrode does not have at least an 8-foot contact with soil.

For such locations, the Engineer will advise the Contractor how to proceed.

2. **Grounding electrode testing:** Primary grounding electrodes shall be tested after each 10-foot grounding electrode and/or section thereof is installed using the fall of potential (three-point measurement) method. After the primary grounding electrode is installed and tested, the Contractor shall connect to the augmented electrode(s) to conduct a system test. The Contractor shall disconnect the grounding electrode conductor from the service equipment ground bus and bonding bushing before testing the grounding electrodes/system. The Contractor shall test the grounding electrode as required by the manufacturer’s instructions for the type of earth testing equipment. The Contractor shall record the readings on a form provided by the District Traffic Engineering Office. The completed form shall be signed and submitted to the Engineer after installation of the electrical service grounding.
- (b) **Excavation for Foundations:** Excavation shall be performed in accordance with the requirements of Section 401.
- (c) **Concrete Foundations:** Concrete foundations shall be constructed and cured in accordance with the requirements of Section 404 and shall rest on material that will adequately support the design load. The Contractor may secure the anchor bolts to prevent their movement during concrete placement with a No. 3 or smaller rebar. Rebar shall be attached to the anchor bolts with rebar twist ties. Exposed areas of concrete foundations shall be given a Class 7 finish in accordance with the requirements of Section 404. Items shall not be erected on concrete foundations until concrete has cured for at least 28 days or has obtained a compressive design strength of at least 3,000 pounds per square inch.

Foundations for overhead sign structures shall be spread footings unless inadequate soil conditions require deep foundation systems, i.e., drilled piers, driven piles. Drilled foundations may be permitted except for single-pole structures, i.e., overhead single-pole-in-end forms, cantilever, or butterfly.

Foundation designs for signal poles, high-mast lighting poles, and overhead sign structures shall be furnished by the Contractor. Designs shall indicate the cubic yard quantity of concrete required for the foundations. Foundations shall be designed to conform to the requirements of the same edition of AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* used for the structure it is supporting. The Contractor shall accomplish at least one test bore, as approved by the Engineer, at each foundation location to determine the subsurface conditions prior to designing the foundation. Test bores shall be performed in accordance with any of the following three methods:

1. ASTM D 420, ASTM D 1452, and ASTM D 1586
2. ASTM D 3441
3. ASTM D 4719.

For areas west of I-95, the depth of the test borings shall be at least 15 feet; for areas east of I-95, the depth of the test borings shall be at least 30 feet. When test borings are performed in the median of I-95, their depth shall be at least 15 feet for areas north of the intersection with Route 250 and at least 30 feet for areas south of the intersection with Route 250. Soil conditions shall be tested at the ground level and then at depth intervals of 3 feet in accordance with any of the three methods stated.

When auger refusal or a count of 50 blows per inch occurs before a 15-foot depth due to rock, the rock shall be continuously cored for at least 5 feet and be sampled in accordance with ASTM 2113. Boring logs shall be properly identified to the actual site with the centerline station and the distance perpendicular from the centerline indicated. On projects where the roadway is existing and no centerline is being surveyed, alternate methods for identifying the location shall be submitted by the Contractor for the Engineer's records. Bore log data shall be submitted electronically in an approved format, in accordance with Materials Division Policy and the resulting borehole log shall be included with the shop drawing submittals for the foundation designs.

The quantity of cubic yards of concrete that is indicated in the contract is an approximation. Payment will be made for the actual cubic yards of concrete based upon the foundation design supplied by the Contractor.

Test bores shall be performed within 5 feet of the foundation's location, as shown on the plans, or as directed by the Engineer.

- (d) **Electrical Service:** Electrical service shall be installed in accordance with the requirements of the NEC and the local power company. Meter bases and current transformer cabinets will be furnished by the local power company. The Contractor shall make arrangements with the local power company for pickup of this equipment. The Department will request and pay for electrical service and temporary electrical service for items temporarily relocated or adjusted for the purpose of traffic control shown on the plans or directed by the Engineer. If the Contractor desires temporary service for his convenience, he shall arrange and pay for the service.
- (e) **Poles, Posts, and Sign Structures:** The location of each pole, post, and sign structure shall be established by the Contractor with a stake bearing the number or identification designated on the plans. The Engineer, accompanied by the Contractor, will inspect the locations

and advise the Contractor of any necessary adjustments. Poles, posts, and sign structures shall be made plumb after installation of loads by the use of nuts and flat washers above and below the base plate on each anchor bolt or by other approved methods.

If a pole, overhead sign structure, or span wire is to be located within 10 feet of an electric power line as measured in any direction, the Contractor shall immediately inform the Engineer. The Contractor shall not install the equipment until the Engineer has reviewed and advised the Contractor of any relocation or to proceed with the work.

A noncorrosive metal identification tag shall be permanently attached approximately 30 inches above the foundation to each signal, pedestal, and lighting pole; overhead sign structure; bridge-mounted sign structure; and steel sign post except U-channel sign posts and square tube steel. The tag shall be of sufficient size for 1/4-inch lettering, single-spaced between lines, and shall be attached by noncorrosive screws or rivets.

The tag shall be imprinted with "VDOT" except when the structures are located within an incorporated town or city on a primary or secondary roadway, where it shall be imprinted with the municipality's name unless otherwise noted on the plans or directed by the Engineer. The tag shall also be imprinted with the following:

1. Manufacturer's name on all tags.
2. Manufacturer's unique ID number on all tags.
3. Date of manufacture on all tags.
4. Signal poles: gage and length of pole and mast arm(s).
5. Pedestal poles: gage and length of pole.
6. Lighting poles: gage and length of pole and luminaire arm(s); electrical phase circuit designation.
7. Overhead sign structures: gage and length of pole and span.
8. Steel sign posts: I-beams: length, size, and weight per foot of post.

When transformer bases are used, bolt covers shall be installed on pole anchor bolts. Bolt covers shall be designed to allow ventilation of the nut and anchor bolt.

Poles shall be provided with hand holes that face away from traffic. Hand holes shall be at least 3 by 5 inches unless otherwise specified and shall be provided with a gasket and cover with an 18-inch-long galvanized chain with a minimum breaking strength of 300 pounds welded to the inside of the pole at the bottom of the hand hole opening and to the inside of the cover to prevent accidental loss. The cover shall be attached to the pole with noncorrosive captive screws, and attachment holes shall be drilled and tapped.

When required by the plans, the Contractor shall supply a terminal strip consisting of 24 double-pole terminals. The terminal strip shall be constructed of noncorrosive materials and shall be located on the outside of the pole just above the hand hole. A continuously welded

frame and a removable, weatherproof, gasketed cover designed to enclose both the hand hole and terminal strip shall be provided.

- (f) **Breakaway Support Systems:** Breakaway support systems shall be installed on lighting poles when required by the plans and on pedestal poles except when used for power service. Breakaway support systems shall be installed in accordance with the requirements of the manufacturer's recommendations.
- (g) **Conductor Cables:** Conductor cables in conduit runs more than 100 feet in length shall be installed with the use of an approved lubricant or pulling compound. Cleaning agents and lubricants that have a deleterious effect on cable coverings shall not be used.

Aerial cables that extend more than 20 feet shall be supported by a span wire or reinforced with a copper-clad, galvanized, or stainless steel wire for self-support. Cable rings shall be used to attach conductor cables to the supporting wire; however, lash wire may be used to attach interconnect cable when no other conductor cables are attached to the same span wire. Vinyl tape shall be used as shown on the plans to prevent sag. When aerial cables enter a service entrance head, an 8-inch drip loop shall be formed.

Bends in single or multiple conductor cables shall have a bend radius of at least 5 times the outside diameter of the cable.

Conductor cables shall be installed with the slack length coiled in junction boxes. The coiled length shall be sufficient to allow cables to extend at least 2 feet above junction boxes.

Solderless terminals shall not be used for connecting conductor cables having solid conductors to terminal posts.

Splices in lighting conductor cables will be permitted only at accessible locations. Splices in service entrance conductor cable will be permitted only for connection to the utility company's service conductor cables. Splices will not be permitted in signal and interconnect conductor cables.

Splices in lighting and service entrance conductor cables shall be made in accordance with the requirements of the NEC and the following additions and exceptions. Conductor insulation shall be removed only to the amount necessary to install the connector. Exposed conductors shall be wire brushed and cleaned before splicing. Splices shall be made with properly sized non-insulated butt-end connector compression sleeves for single conductors or split bolts for branch circuit connections. Conductor connections shall be made mechanically and electrically secure. Crimping tools used on compression sleeves shall be designed for the application and sized to the splicing connectors.

Splices shall be covered with an insulation rated equal to or higher than the voltage rating of the conductor cable. Single and branch circuit conductor splices shall be properly re-insulated and made water resistant by one of the following methods:

- Two layers of rubber electrical tape shall be applied half-lapped with the first layer extending the length of the disturbed insulation and the second layer extending at least 1 inch onto clean undisturbed insulation of each conductor. Rubber electrical tape shall be stretched and wrapped tightly to eliminate air gaps. Rubber electrical tape shall be

molded around irregular shapes and multiple conductors for smooth insulation buildup. Over the rubber electrical tape, at least two layers of vinyl electrical tape shall be applied half-lapped with each layer overlapping the end of the preceding layer by at least 1 inch onto clean, undisturbed insulation. The splice and at least 1 inch of adjacent clean insulation shall be covered using an acceptable water-resistant sealing compound for electrical splices;

- Heat-shrink tubing properly sized shall be installed extending at least 3 inches onto each end of clean, undisturbed insulation. End seams around two or more adjacent conductors shall be sealed and made water resistant; or
- The splice kit shall be properly sized to extend at least 3 inches onto each end of clean, undisturbed insulation.

Single conductor splices within a multi-conductor cable shall be re-insulated using heat-shrink tubing.

Re-jacketing of multi-conductor cables shall be accomplished using heat-shrink tubing properly sized.

Heat-shrink tubing shall be heated using a non-contact flameless device or a flamed heat source device equipped with a shield to prevent the flame from coming in contact with the tubing.

Breakaway connectors shall be installed on luminaire conductors and on signal conductors for signal head assemblies on pedestal poles. Breakaway connectors shall be fused for the hot conductors and nonfused for the grounded conductor. Breakaway connectors shall be located in the hand hole of the pole.

Signal and interconnect cable terminal strips shall be sealed with a moisture block compound to prevent moisture from entering the open cable end. The compound shall be soft, pliable, and easily removable and shall be used in accordance with the manufacturer's recommendations.

Termination of interconnect cable will be allowed only in a master controller cabinet, local controller cabinet, or terminal enclosure. The cable shield shall be grounded at each termination point. Whenever the cable is entered for connection to equipment, each wire of the cable shall be connected to a terminal post position.

The Contractor shall conduct a Megger test on the installed interconnect cable and shield, for which a reading of 100M ohms shall be required. Testing for 300-volt cable shall be performed at 200 volts, and testing for 600-volt cable shall be performed at 500 volts. Cables shall be disconnected from controller cabinet terminals during testing.

Service entrance and lighting conductor cables shall be marked in accordance with the requirements of Article 310-11 of the NEC. Markings shall be continuous and permanent. Signal and interconnect conductor cables shall be marked in accordance with the requirements of the applicable IMSA specification.

Prior to energizing an electrical system, the Contractor shall demonstrate to the Engineer that the system is clear and free from short circuits, open circuits, and unintentional grounds. Faulty circuits shall be repaired or replaced by the Contractor at his expense.

1. Electrical service and lighting conductor identification:

Grounded conductors: Insulated grounded conductors (Neutrals) shall be identified by a continuous white or gray outer finish except that those larger than No. 6 AWG may be identified by three continuous white stripes on other than green insulation along its entire length.

Equipment grounding conductors: Equipment grounding conductors shall be bare, covered, or insulated. Covered or insulated equipment grounding conductors shall have a continuous outer finish that is either green or green with one or more yellow stripes.

Ungrounded conductors: Ungrounded conductors, whether used as a single conductor or in multiconductor cables, shall be finished to be clearly distinguishable from grounded, grounding, and equipment grounding conductors. Ungrounded conductors shall be identified by a continuous color-coding outer finish by phase and system except that those larger than No. 6 AWG may be identified only at readily accessible locations by marking tape, tagging, or other approved means in accordance with NEC requirements.

Color-coding shall be as follows:

Circuit Designation	Color Code
2-wire circuits, 120 volts; 3-wire circuits, 120/240 volts; 3-phase, 4-wire wye circuits, 208/120 volts; and 3-phase, 4-wire delta circuits, 240 volts	
Phase A or Line A	Black
Phase B or Line B	Red or orange*
Phase C	Blue
Grounded Conductor (Neutral)	White or gray** (see exception above)
Equipment Grounding Conductor	Bare, green, or green with one/more yellow stripes
3-phase, 4-wire wye circuits, 480/277 volts; 3-phase, 3-wire delta circuits, 480 volts	
Phase A	Phase A
Phase B	Phase B
Phase C	Phase C
Grounded Conductor (Neutral)	Grounded Conductor (Neutral)
Equipment Grounding Conductor	Equipment Grounding Conductor

*For 3-phase, 4-wire delta circuits, Phase B shall be the high leg and shall be orange.

**For outer covering of conductors of different systems that is contained within the same enclosure, refer to Article 200 of the NEC.

Electrical service and lighting conductors shall be permanently identified in accessible locations (hand holes, transformer bases, junction boxes, control centers, etc.) with non-ferrous metal tags or nylon tags attached to the conductor. Identifications shall be stamped or engraved on the metal tags and lettered with permanent ink on the nylon tags. Identifications shall be legible and shall indicate the electrical phase. Lighting conductors shall also indicate the electrical phase circuit designation. When the con-

ductors are within a multi-conductor cable, the tag shall be attached to the cable jacket and shall indicate the required information for all conductors on one tag. If the conductors of a multi-conductor cable have been exposed for splicing, connections, etc., the conductors shall be tagged in lieu of the cable jacket.

2. **Signal and interconnect cable** jackets shall be permanently identified by integral-impregnated color coding. Color coding for signal cable shall be as follows:

Cable Insulation Color	14/12 Cable	14/7 Cable	14/4 Cable	14/3 Cable
Red	Red	Red	Red	Don't Walk
Orange	Yellow	Yellow	—	—
Green	Green	Green	Green	—
Red with black tracer	Red	—	—	—
Orange with black tracer	Yellow	—	—	—
Green with black tracer	Green	—	—	—
Blue	Green	Green	—	—
White with black tracer	Yellow	Yellow	—	—
Black	Red	Red	Yellow	Walk
Black with white tracer	Spare	—	—	—
Blue with black tracer	Spare	—	—	—
White	AC Ground	AC Ground	AC Ground	AC Ground

Signal and interconnect cables shall be permanently identified in the controller cabinet, junction boxes, hand holes, and other accessible locations. Signal conductor cables shall also be identified in the hand hole of poles if the cables are attached to terminal strips in the hand hole. Identifications shall be indicated on nonferrous metal tags or nylon tags attached to the cable with nylon cable ties. The identification shall be stamped or engraved on the metal tags and lettered with permanent ink on the nylon tags. Identifications shall be legible and shall conform to the following:

- a. **Signal cable:** phase and location of signal head; e.g., 1 NB left-turn head; 1 NB inside left-turn head; 2 SB through-lane heads; 1 left-turn head and 6 through-lane heads; 2 Ped head NW Quad.
 - b. **Interconnect cable:** description and direction from location (if cable is a spare). The word "spare" shall be included after "inter." The direction from location is required only in the controller cabinet, e.g., Inter. NB; Inter. Spare NB; Inter. WB; Inter.
- (h) **Conduit Systems:** Conduit systems shall be rigid except where contract documents specify otherwise. PVC, fiberglass, and metal conduit runs shall have the minimum number of couplings permitted by the use of standard conduit lengths. Ends of conduit sections that must be field cut shall be reamed smooth. PE conduit shall be installed in continuous unspliced runs between enclosures. Field-threaded portions of metal conduit shall be galvanized. Except for expansion couplings, conduit sections shall be connected with couplings so that ends will abut squarely inside couplings.

Joint-sealing solvent shall be used as recommended by the conduit manufacturer. Where necessary, ends of each length of nonmetallic conduit shall be tapered by machining to provide joints that are tight after assembly.

Conduits shall be continuous and watertight between outlets. Deformed conduit shall not be used. Conduits shall be free from kinks or defects that would cause damage to conductor cables when pulled. Conduits shall be installed so that moisture will drain properly to electrical junction boxes or drainage tees with drip spouts.

After installation, each conduit shall be tested in the presence of the Engineer for obstructions. A suitable rigid or flexible mandrel having a diameter at least 80 percent of the inside diameter of the conduit shall be pulled through each conduit run. Obstructions shall be removed, and the conduit repaired at the Contractor's expense.

After testing, individual non-metallic conduit runs more than 150 feet in length that are to remain empty shall be equipped with a woven polyester or aramid pull tape having a tensile strength of at least 1,100 pounds and less than 15 percent elongation at yield. Pull rope shall not be used in non-metallic conduit. Twelve inches of pull tape shall be doubled back into the conduit at each end.

Metallic conduit runs more than 150 feet in length that are to remain empty shall be equipped with either a pull rope or tape having a tensile strength of at least 1,100 pounds. Twelve inches of pull tape or rope shall be doubled back into the conduit at each end.

Open ends of unused conduit shall be closed with watertight plugs or caps to seal against moisture. Open ends of conduits with conductors installed shall be sealed with an approved soft, pliable, and easily removable waterproof sealant. The sealant shall not have a deleterious effect on cable coverings.

Metal conduit systems shall be bonded. When a nonmetallic conduit system is used, the Contractor shall furnish and install an equipment grounding conductor to maintain a bonded system in accordance with the requirements of the NEC.

Non-metallic conduit with non-metallic cable (fiber optic) within shall be equipped with a No. 8 locator wire.

Wherever conduit crosses a structural expansion joint, conduit shall be provided with an expansion fitting. The fitting shall permit longitudinal movement of the amount specified on the plans.

1. **Exposed conduit systems** shall be fabricated of heavy-wall PVC, fiberglass, or metal, with not more than four bends between any two outlets. The angular sum shall be not more than 360 degrees. When heavy-wall PVC or fiberglass conduit is accessible to public contact, it shall be covered with a protective shield conforming to the requirements of Section 238 for a distance of at least 8 feet above the adjacent finished grade. Splice boxes or pull boxes shall be of a size that will allow proper termination of conduit and connection of conductor cables as required by the NEC. Conduit shall be terminated by means of approved fittings or bushings.
2. **Buried conduit systems** shall be installed in straight lines between outlets. When obstructions are encountered during installation and conduit cannot be economically lo-

cated elsewhere, the obstruction shall be bypassed by offsetting the conduit line in accordance with the requirements of the Standard Drawings. Required conduit bends shall be installed with a bend radius of at least 5 feet. Conduit bends in structures and foundations shall be installed in accordance with the requirements of the NEC. The use of a pipe tee or vice for bending conduit will not be permitted.

When conduit is to be installed under an existing roadway, entrance, or fixed object and open cutting is not permitted, conduit shall be installed by an approved directional boring method. Conduit for the directional boring method shall be PVC designed specifically for the directional boring operation or high-density PE. With the approval of the Engineer, the Contractor may elect to use the jacked method to install a pipe sleeve for installation of the required conduit at no additional cost to the Department.

Open cut areas shall be backfilled in accordance with the requirements of Section 302.

- (i) **Junction Box Covers:** If a special tool or wrench is needed to remove a cover, the Contractor shall furnish the Engineer five such tools.
- (j) **Hydraulic Cement Concrete Sidewalk:** When disturbed by the installation of equipment, sidewalk shall be replaced in accordance with the requirements of Section 504 along existing joint lines.

700.05—Measurement and Payment

Concrete foundations will be measured and paid for in units of each or cubic yards of concrete as applicable. When paid for in cubic yards of concrete, no payment will be made for concrete in excess of the cubic yards of concrete required by the foundation design unless otherwise approved by the Engineer. This price shall include foundation design, concrete, reinforcing steel, stub poles, anchor bolts, bolt circle templates, grounding equipment, conduits, excavating, backfilling, compacting, disposing of surplus and unsuitable material, and restoring existing areas.

Electrical service will be measured in units of each and will be paid for at the contract unit price per each. This price shall include service poles, safety switches or breaker boxes, service entrance conductor cables from the utility company's service box, conductors to the safety switch and circuit breaker box, conduits and fittings on poles and steel supports, conduit straps or clamps, meter base, service entrance heads, thimbleye bolts, steel supports, wireway, junction boxes for grounding electrode and utility service, excavation, concrete, and pickup and installation of meter base and current transformer cabinet.

Luminaire arms will be measured in units of each and will be paid for at the contract unit price per each. This price shall include pole mounting brackets, fittings, and mounting hardware.

Lighting poles will be measured in units of each and will be paid for at the contract unit price per each. This price shall include pole shafts, luminaire arms, grounding lugs, hand holes and covers, caps, identification tags, anchor bases, bolt covers, bracket arms, and breakaway support systems.

Signal poles will be measured in units of each and will be paid for at the contract unit price per each. This price shall include pole shafts, mast arms, grounding lugs, hand holes and covers, caps, fittings, anchor bases, bolt covers, and identification tags.

Overhead and bridge-mounted sign structures will be measured in units of each and will be paid for at the contract unit price per each. This price shall include structural units and supports, hand holes and covers, grounding lugs, walkways and handrails, electrical systems including conduit and fittings, and identification tags.

Sign posts will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include clamps, identification tags, and breakaway base assemblies.

Pedestal poles will be measured in units of each and will be paid for at the contract unit price per each. This price shall include caps, breakaway support systems, hand holes and covers, grounding lugs, identification tags, and anchor bases and bolt covers.

Wood poles will be measured in units of each and will be paid for at the contract unit price per each. This price shall include thimbleye bolts, guy wires with guards and anchors, excavating, backfilling, compacting, disposing of surplus and unsuitable material, and restoring existing areas.

Conductor cables will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include conductors, breakaway connections, markings and identifications, splice kits, electrical tape, testing, and connections.

Conduit will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include conduit bodies, fittings, bonding systems, pull ropes, pull tapes, plastic spacers, No. 8 locator wire when required, pull or splice boxes with an area of 512 cubic inches or less, supports, and protective metal shields.

Trench excavation will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include trenching, encasing, backfilling, locator tape, compacting, disposing of surplus and unsuitable material, and restoring existing areas.

Junction boxes will be measured in units of each and will be paid for at the contract unit price per each. This price shall include concrete collars, frames and covers, tools to remove the cover, ground rods, ground conductors, grounding lugs, knockouts, cable racks, aggregate, excavating, backfilling, compacting, disposing of surplus and unsuitable material, and restoring existing areas.

These prices shall include providing the required finish.

Test bores will be measured in units of each and will be paid for at the contract unit price per each. This price shall include the test bore, rock sampling, and determination of the soil and rock condition.

Electrical service grounding electrode will be measured in units of each, per 10-foot electrode or portion thereof, and will be paid for at the contract unit price per each. This price shall include testing, exothermic welds, grounding electrode(s), electrode couplers, grounding conductor, and report documentation.

Bored conduit will be measured in units of linear feet and will be paid for at the contract unit price per linear foot for the size specified. The price shall include conduit; fittings; couplings; and, when required, No. 8 locator wire, bonding systems, and pull rope or tape.

Payment will be made under:

Pay Item	Pay Unit
Concrete foundation (Standard, type, and size)	Each or Cubic yard
Electrical service (Standard and type)	Each
Luminaire arm (Length)	Each
Lighting pole (Standard, luminaire mounting height, and length of luminaire arm)	Each
Signal pole (Standard, length, number, and length of arms)	Each
Overhead sign structure (Location)	Each
Bridge-mounted sign structure (Location)	Each
Sign post (Type and size)	Linear foot
Pedestal pole (Standard and length)	Each
Wood pole (Class and length)	Each
Conductor cable (Size/number)	Linear foot
Conduit (Type and size)	Linear foot
Trench excavation (Standard)	Linear foot
Junction box (Standard)	Each
Test bore	Each
Electrical service grounding electrode (10 foot)	Each
Bored conduit (size)	Linear foot

SECTION 701—TRAFFIC SIGNS

701.01—Description

This work shall consist of furnishing, fabricating, refurbishing, and erecting signs as specified on the plans.

701.02—Materials

Reflective sheeting shall conform to the requirements of Section 247.

701.03—Procedures

(a) Fabrication:

1. **Aluminum welds:** Aluminum shall be welded in accordance with the requirements of Section 407.
2. **Sign panels:** Panels shall be fabricated of aluminum 0.100-inch thickness and shall be smooth, flat, and free of metal burrs and splinters. Sign panels for overlays shall be 0.080-gage aluminum alloy conforming to the requirements of Section 229.02(a).
3. **Applying reflective background sheeting:** Sheeting shall be applied in accordance with the requirements of the manufacturer's recommendations.

A single piece of applied sheeting shall be at least 4 by 4 feet on sign panels 16 square feet or more in area, except for sign panels fabricated with fluorescent prismatic lens orange sheeting. Sign panels 16 square feet or more in area and fabricated with fluorescent prismatic lens orange sheeting shall consist of sheeting at least 4 by 2 feet except that one piece of sheeting may be less than 2 feet wide to obtain the exact dimension required. Joints, splices, or laps will not be permitted on sign panels less than 16 square feet in area except for the following:

- a. One factory splice from the roll will be permitted.
- b. One joint will be permitted on fluorescent prismatic lens orange signs when one dimension of the panel is greater than 36 inches and less than 48 inches.

When more than one width of sheeting, except fluorescent prismatic lens orange, is applied to a sign panel, sheeting edges shall form a vertical butt joint or may overlap not more than 3/8 inch. Where horizontal joints are used, except for fluorescent prismatic lens orange sheeting, the bottom edge of the top sheeting shall lie over the top edge of the next lower sheeting in a shingle lap of not more than 3/8 inch. Multiple pieces of fluorescent prismatic lens sheeting shall be installed with a gap 1/32 to 1/16 inch between the edges. Sheeting shall be carefully matched to maintain uniform shading and prevent contrast between widths of sheeting.

The finished sign shall be free from cracks, gaps, streaks, wrinkles, blisters, discoloration, buckles, and warps and shall have a smooth surface of uniform color.

4. **Letters, numerals, arrows, symbols, borders, and other features of the sign message:** Features of the sign message shall conform to the requirements of the *MUTCD*. Units of the sign message shall be formed to provide a continuous stroke width with smooth edges; present a flat surface free from warps, blisters, wrinkles, burrs, and splinters; and conform to the following:

- a. **Type L1, screen process, applied:** Features shall be produced by a direct or reverse screening process approved by the Engineer. Sign messages and borders that are darker than the sign field shall be applied to the reflective sheeting by a direct process. Sign messages and borders that are lighter than the sign field shall be produced by the reverse process in which the message and border are outlined by a color that is darker than the paint or the sheeting on the sign field. Transparent colors, inks, and paints used in the screening process shall be of the type and quality recommended by the sheeting manufacturer.

Screening shall produce a uniform color and tone. Edges of the legend and borders shall not have blemishes.

Signs shall be air dried or baked in accordance with the manufacturer's recommendations to provide a smooth, hard finish.

- b. **Type L2, plastic film sheeting, applied:** Features of the sign message shall be cut from plastic film sheeting of the color specified on the plans. Sheeting shall be an elastomeric pigmented film suitably compounded and processed, coated on one side with an adhesive, and covered with a paper liner that shall be removable from the adhesive without being moistened. Adhesive shall be activated by heat or a

solvent recommended by the sheeting manufacturer and shall be suitable for use with a hand roller, squeeze roller, or vacuum applicator that will form a durable bond to wood, metal, plastic, porcelain enamel, paint lacquer, and reflective sheeting. Sheeting shall be at least 0.002 and not more than 0.0035 inch in thickness and sufficiently opaque so that its color will be unaffected by the color of the sign field.

- c. **Type L3, cutout, reflective sheeting, and pressure applied:** Features of the sign message shall be cut from approved reflective sheeting of the color specified on the plans. Sheeting shall have heat-activated or pressure-sensitive adhesive and be applied to the background sheeting in accordance with the requirements of the manufacturer's recommendations.
 - d. **Type L4, overlay film, pressure applied:** Features of the sign message are created by using a background sheeting of the color needed for the sign message and then applying the overlay film with the sign message areas removed from the film. The overlay film shall be transparent and shall be of the color needed to provide the correct background color of the sign.
5. **Joining sign base panels:** Horizontal joints will not be permitted. Where multiple vertical panels adjoin, the face and edges shall be milled or finished to a tolerance of $\pm 1/32$ inch from a straight plane such that no gap more than 1/16 inch is allowed between panels.
 6. **Applying the sign message:** Features shall be straight, properly spaced, smooth, and free from irregular edges.
 7. **Sign finishing:** The complete outer edge, splices, messages, and borders of signs shall be sealed after application to the sign panel. Sealant material and its application shall be in accordance with the sheeting manufacturer's recommendations.
 8. **Rejected sign messages:** Sign messages rejected by the Engineer shall be immediately obliterated by the Contractor.
- (b) **Transporting and Storing Signs From the Fabricator:** Signs shall be transported in accordance with either of the following methods.
1. Signs shall be transported in cardboard cartons with a slipsheet covering the sheeting. The slipsheet shall be paper with a plastic coating on one side with the plastic placed toward the sign sheeting in accordance with the sheeting manufacturer's recommendations. Not more than 10 signs may be placed in one carton. Signs shall alternate face-to-face, back-to-back, throughout the carton. A microfoam pad at least 1/16 inch in thickness shall be placed between signs placed face to face. Cartons shall be placed vertically within a container designed to elevate boxes above ground level and provide lateral structural support. Cartons shall not be exposed to moisture during transportation; or
 2. Signs shall be transported on an open truck or trailer bed with vertical racks for attachment of signs. Racks shall be designed to provide lateral structural support and allow the free flow of air around the sign face. Large signs may be transported on an open truck or trailer bed in shipping containers consisting of framing around edges of signs.

Framing shall be nontreated lumber that will provide support for the sign without allowing pressure on the sign sheeting. Each container may house two signs positioned with the sign sheeting facing toward the inside. Signs shall be held in place in containers through the use of metal stiffeners attached to the framing, T-bars and Z-bars, and horizontal stiffeners. Shipping containers shall be secured in the vertical position for transportation.

Signs transported in cardboard cartons shall be stored in original shipping containers in a dry, enclosed location providing protection from extreme heat and humidity. Signs transported on racks or in wooden containers shall be stored on vertical racks designed to elevate signs above ground level, provide lateral structural support, and allow the free flow of air around the sign face. Signs shall not be stored where they are subjected to water runoff.

Signs may be removed from storage and installed on their structural supports before the structure is erected. The structure along with the sign shall be erected within 24 hours after removal of the sign from storage. During this time period, the sign and its structural support shall be stored at a sufficient angle to facilitate water runoff from the sign while preventing the sign from coming in contact with the ground.

Signs shall not be banded together, covered with tarps, stored flat, or subjected to pressure on the sign sheeting.

Signs transported or stored in cardboard cartons that have been exposed to moisture to the extent that moisture has entered the cartons will be rejected. The Contractor shall immediately obliterate the sign message and remove rejected signs from the project.

- (c) **Transporting and Storing Relocated Signs:** Relocated signs shall be transported and stored in a manner that will not allow pressure to be placed on the sign sheeting. Relocated signs shall be stored in their vertical position above ground level. Relocated signs that have been removed from their structure shall be stored in accordance with the requirements of (b) herein.
- (d) **Erection:** Vertical clearance for overhead and bridge-mounted sign structures shall be no less than 19 feet 0 inch and no more than 21 feet 0 inch from the bottom of the lowest mounted sign panel to the crown of the roadway unless otherwise specified on the plans. Walkway or luminaire assemblies shall have a vertical clearance of no less than 17 feet 6 inches from the bottom of the assembly to the crown of the roadway. Sign panels shall be installed during a sequence of construction as required to provide necessary traffic control. When possible, sign panels shall be installed at a time when covering of the sign message will not be needed. When this is not possible, a porous cloth cover rendering the sign message nonvisible shall be placed over the sign sheeting, folded over the sign edges, and secured to the back of the sign panel. Sign panels shall be securely fastened to posts or supports and erected plumb. Stud breakage of 10 percent or less of the total number of studs may be repaired with rivets. If breakage exceeds 10 percent, the sign panel will be rejected.

Ground-mounted signs shall be horizontally angled at 93 degrees between the face of the sign and the centerline of the roadway.

Vertical and horizontal spacing between signs shall be 1 inch.

A neoprene gasket 1/16 inch in thickness shall be used between the seat of the galvanized steel post clamps and the framing unit.

Illumination of signs shall be in accordance with the requirements of Section 705.

Damage to reflective sheeting may be repaired and edge sealed in accordance with the requirements of the manufacturer’s recommendations and the following: Sign patch material shall be of the same type and color as the surrounding sheeting and shall have at least the same life expectancy. Patching will not be permitted on any letter, numeral, arrow, symbol, or border. Where the number, size, or spacing of patches is more than the following, the sign will be rejected and shall be replaced at the Contractor’s expense:

Sign Face Area (sq ft)	Max. No. of Patches	Max. Size of Patches (sq in)	Min. Spacing Between Patches (in)
24.99 or smaller	No patching allowed		
25 to 49.99	1	1	0
50 to 99.9	2	1	6
100 to 199.9	3	2	6
200 or larger	4	3	12

Superficial damage to sign panels may be repaired using proper methods to obtain a smooth and flat panel. Sign panels that have more than superficial damage will be rejected and shall be replaced at the Contractor’s expense.

Overlays and demountable message including borders existing on the signs shall be removed to facilitate the installation of the new overlayment. Bullet holes and bent sections shall be flattened so that the sign face is free of projections and large indentations to facilitate installation of the new overlayment.

Overlayments 3 feet or less in total horizontal dimension shall be accomplished with one panel. Overlayments greater than 3 feet in total horizontal dimension shall be accomplished with panels no less than 3 feet wide except that one panel per overlayment may be less than 3 feet wide to obtain the exact horizontal dimension required. Joints shall be tightly butted and not overlapped.

Overlay panels shall be erected with aluminum rivets. Rivets shall be no less than 3/16 inch in diameter and of such length as to fasten the panels securely and form a head conforming to the manufacturer’s recommendations. Rivets shall be located on 1-foot centers, positioned 1 inch from each panel’s edge, around the sign’s perimeter. Where overlayment panels are 30 inches or greater in width, a column of rivets shall be installed on 1-foot centers down the centerline of the panel. Rivets shall be installed in such a sequence as to prevent buckling of the panels.

In the Hampton Roads District, at installations where the existing sign panel is attached by stud welds to the horizontal supports, 3/8-inch galvanized bolts, washers, nuts, and fiber washers shall be used in addition to rivets to attach the overlay panels. Bolts shall be located in alignment with each horizontal support (z-bar, t-bar), positioned 1-foot from each panel’s edge, and spaced on 1-foot-maximum spacings along each horizontal support. At locations

where existing stud welds and panel clips are in the area of the proposed bolt locations, the bolts shall be relocated as needed to miss these. Nuts shall be tightened only to the point just before the sign panel begins to buckle in that area.

701.04—Measurement and Payment

Sign panels will be measured in square feet and will be paid for at the contract unit price per square foot. This price shall include background sheeting, sign messages, framing units, and hanger assemblies.

Overlay sign panels will be measured in square feet of sign panels without deductions for rounding corners. Overlay sign panel will be paid for at the contract unit price per square foot, which price shall be full compensation for verifying the size and color of overlayment panel; removal of existing overlayment and demountable messages including borders; and fabricating, furnishing, and installing overlayment.

Payment will be made under:

Pay Item	Pay Unit
Sign panel	Square foot
Overlay sign panel	Square foot

SECTION 702—DELINEATORS

702.01—Description

This work shall consist of furnishing and installing road-edge, barrier, or guardrail delineators of the type specified in accordance with these specifications and in conformity with the lines and dimensions on the plans or as established by the Engineer.

702.02—Materials

- (a) **Fabrication** of aluminum panels with reflective sheeting shall conform to the requirements of Section 701.
- (b) **Reflective sheeting** shall conform to the requirements of Section 247 and shall be the same color as the adjacent pavement marking.
- (c) **Plastic lens retroreflectors** shall conform to the requirements of Section 235 and shall be the same color as the adjacent pavement marking.
- (d) **Plastic panels** shall conform to the requirements of Section 235.
- (e) **Aluminum panels** shall conform to the requirements of Section 235.

- (f) **Adhesive** for attaching delineators to guardrail and barrier shall be as recommended by the manufacturer.

702.03—General Requirements

(a) **Road-edge Delineators:**

1. **Interstate road-edge delineators** shall consist of two types.
 - a. Type I shall be an aluminum panel with reflective sheeting.
 - b. Type II shall be a plastic lens retroreflector.
2. **Standard and special road-edge delineators** shall be an aluminum panel with reflective sheeting.

- (b) **Barrier and Guardrail Delineators:** Barrier and guardrail delineators shall have no less than 7.0 square inches of retroreflective sheeting and shall have no more than 5 inches of vertical projection when installed. The delineator shall be fabricated from a flexible plastic panel.

702.04—Procedures

- (a) **Road-edge delineators** shall be placed as shown on the standard drawings.
- (b) **Barrier and guardrail delineators** shall be applied to clean dry surfaces in accordance with the manufacturer's recommendations. Loose material and dirt shall be removed from concrete by wire brushing and from steel by appropriate methods. When recommended by the manufacturer, a primer shall be used.

Delineators shall be installed on barriers and guardrails that are within 15 feet of the edge of the pavement.

Barrier delineators shall be installed on the top surface of the barrier wall except that barriers greater than 36 inches in height, barriers with glare screens or handrail attached, and barriers located in construction work zones shall have the delineators installed at a height of approximately 24 inches above the roadway. Delineators installed on the sides of barrier shall be positioned so that the reflective surface lies in the vertical plane facing oncoming traffic. Barrier delineators shall be installed using an adhesive as recommended by the delineator's manufacturer.

Guardrail delineators shall be installed on the web of the guardrail posts. Where guardrail blockouts are installed, delineators shall be installed on the web of the blockouts. Where weak post guardrail and cable guardrail systems are installed, delineators shall be manufactured to fit on the web of the guardrail posts; no field cutting or adjustments will be allowed. If a bolting system is used to attach the delineators to the posts, the bolting system shall be such that no drilling of the guardrail posts or blockouts is necessary. Where wooden support posts or blockouts are used, delineators shall be attached with screws or by an adhesive system as recommended by the manufacturer. Screws shall be stainless steel or galvanized.

Spacing for delineators on barrier or guardrail shall be on 80-foot centers unless otherwise indicated. Delineators mounted on guardrail and barriers located in curves on interchange ramps shall be spaced in accordance with the spacing for interstate road-edge delineators as shown on the standard drawings except that the maximum spacing shall be 80 feet.

Where the center-to-center spacing for delineators on guardrail cannot be obtained due to post spacing, the delineators shall be installed to provide spacing that is not greater than the spacing indicated herein.

702.05—Measurement and Payment

Road-edge delineators will be measured in units of each and will be paid for at the contract unit price per each. This price shall include sign post, fasteners, retroreflective elements, excavation, and backfill.

Barrier and guardrail delineators are considered incidental to barrier and guardrail construction and will not be measured for separate payment unless specified in the Contract. When specified in the Contract for installation on existing barriers and guardrail, delineators will be measured in units of each and paid for at the contract unit price per each. This price shall include surface preparation, adhesive, fasteners, and retroreflectors.

Payment will be made under:

Pay Item	Pay Unit
Road-edge delineator (Standard and type)	Each
Barrier delineator	Each
Guardrail delineator	Each

SECTION 703—TRAFFIC SIGNALS

703.01—Description

This work shall consist of furnishing and installing traffic signal equipment in accordance with these specifications and as shown on the plans or as directed by the Engineer. The terminology used herein and on the plans shall be as generically interpreted by manufacturers in the field except that certain terminology shall be interpreted as follows:

- (a) **Auxiliary equipment:** separate devices used to add supplementary features to a controller, such as conflict monitors, load switches, and flashers.
- (b) **Manufacturer:** the company that assumes the responsibility for producing and assembling the equipment and that is responsible for guaranties and warranties for the equipment.
- (c) **System:** the coordination of traffic signals through a time relationship or by interconnection of controllers with a master controller or computer to permit coordinated movement along a street(s).

- (d) **System manufacturer:** the company or system supplier that assumes the responsibility for procuring and assembling the equipment and that is responsible for guaranties and warranties for the equipment.

703.02—Equipment

Traffic signal controllers, master controllers, auxiliary equipment, and flashers for operating flashing beacons furnished by the Contractor shall be certified by the manufacturer as conforming to the requirements of NEMA TS-1 and any exceptions and additions stated herein unless otherwise specified. The manufacturer shall also provide certification from an independent testing laboratory that the model of controller, auxiliary equipment, and flasher furnished conforms to NEMA environmental standards and test procedures. Controllers and auxiliary equipment shall be the manufacturer's standard design. Controllers shall be furnished completely housed in a weatherproof cabinet. Controllers and auxiliary equipment shall operate from a 120-volt, 60-Hz, single-phase, AC power supply. The manufacturer's name, model number, serial number, and part identification number shall be permanently attached to the cover of the equipment. The Contractor shall furnish the manufacturer's instructions for installing and maintaining the equipment.

The Contractor shall provide at least 15 hours of training for Department personnel in the operation, timing, maintenance, and repair of the signal equipment supplied by the Contractor. Training shall consist of at least 50 percent hands-on training. Training shall be held at a location specified by the Engineer and conducted by a qualified instructor representing the equipment manufacturer. Training material shall contain "hand-outs" for each attendee that shall serve not only as subject guidance, but also as quick reference material for future use by the students. The Contractor shall also provide training on VHS tapes or digital video disc (DVD).

The Contractor shall secure assistance from the manufacturer as necessary to produce, implement, and fine-tune the controller, coordination, and preemption timings required to provide for an orderly movement of traffic as approved by the Engineer. Coordination timings shall include plans for morning and afternoon peak hours and off-peak conditions. The Department will furnish traffic counts for the Contractor's use in producing the timings within 30 days of the Contractor's request to the Engineer. The Contractor shall furnish to the Engineer three copies of the timing data and documentations used in calculating the timings. These data shall be submitted for approval 60 days prior to timing implementation. When specified on the plans, the Department will supply the final timing plan for implementation and fine-tuning by the Contractor. The Contractor shall request the final timing plan at least 90 days in advance of implementation.

- (a) **Traffic Signal Controllers:** Controllers shall be eight phase, traffic actuated, solid state, and digital. Controllers shall be capable of operation in a closed loop traffic control system by the addition of a communication module/board and closed loop system software. No additional changes to the controllers shall be required. Controllers shall be completely modular consisting of a main frame and plug-in modules/boards that can be secured in place but easily removed for inspection and servicing.

Controllers shall also include the following programmable features:

- Volume density functions.
- Pedestrian functions.

- Four signal overlaps with extension timing capability to allow the overlap green to extend beyond the parent green by a user programmable time. Amber and all red clearances shall be programmable for the overlaps when extension timing is used.

Phasing:

- Concurrent phasing.
- Sequential phasing in ascending numerical order.
- Concurrent phasing on one side of the barrier (compatibility line) and sequential phasing on the other side.
- Reversal of phases in the same ring on the same side of the barrier.

Soft recall: Places a demand on a phase(s) when no other calls exist.

Conditional service: Allows an odd phase to be reserviced after the even phase but prior to crossing the barrier provided the following conditions are met:

- Even phase in the same ring has gapped out and is resting.
- A call exists across the barrier.
- Even phase in the opposite ring is still extending with enough time left in its max timer. Time shall be equal to or greater than the minimum green of the phase about to be served plus the even-phase-same-ring's clearance times.

Last car passage: Allows for timing a full passage time when a phase gaps-out.

Security code:

- When enabled, a user-specified security code is required to be entered before data may be changed. Security access shall be automatically rescinded 10 minutes after the last user keystroke or 10 minutes after access if there are no user keystrokes. Viewing of data shall not require the entering of the security code. In closed loop systems, central equipment shall have free access to data within the local controllers via the master controller regardless of security codes imposed at the local controllers.
- Controllers shall have an auxiliary connector mounted on the front panel that will allow the following functions to be accomplished in accordance with the Electronic Industries Association's RS-232C interface standard. Accomplishment of these functions shall be capable while the controllers are in normal operation without any adverse effects.

Data transfer: All user-entered data shall be transferable to other controllers of the same manufacturer and model through the use of a data transfer cable connected to the auxiliary connector on the controllers. Messages shall be displayed on the LCD when transfer is completed and when there is an error in transmission. The Contractor shall furnish two data transfer cables to the Department unless otherwise indicated on the plans.

Downloading and uploading of data:

- Menu-driven computer software developed by the controller manufacturer shall provide for the downloading and uploading of user-entered data between the controllers and an IBM or IBM-compatible computer with a 20MB minimum hard drive and operation of the following functions.
 - Creation, review, and modification of user entered data.
 - Creation, review, and modification of intersection configurations including, but not limited to, graphic display of intersection geometrics, laneage, street names, phases, and overlaps. Standard intersection geometric graphics consisting of at least a four-leg approach, tee, offset tees, and diamond interchanges that are user-selectable for use in creating intersection configurations shall be included in the software.
 - Transfer of user-entered data except real time and date from one intersection's database to another intersection's database.
 - Comparison of an intersection's database and reports stored on disk to that uploaded from the intersection's controller. Differences shall be indicated.
 - Storage and retrieval of an intersection's database and configurations to and from diskettes.
 - Printout of an intersection's database through a printer.
 - Display of controller status while connected to the controller.
- The number of intersections whose database and configurations can be stored, retrieved, and downloaded from and to a diskette shall be limited only by the availability of space on the diskette. Each intersection file shall be uniquely identified and accessible by an alphanumeric name. Cross-referencing of the alphanumeric name to the intersection name shall be provided if different.
- Connection of the controller to the computer shall be accomplished through the use of a cable with a DB-9 female connector on one end for connection to the computer and the appropriate connector on the other end for connection to the controller auxiliary connector.
- The Contractor shall furnish the manufacturer's certification that software on an approved format and connecting cables are available that will provide for operation of the specified functions.

Printing:

- User-entered data and reports shall be capable of being downloaded to a serial printer in a usable format. Data to be printed shall be selectable by the user from at least the following submenus:
 - Controller

—Coordination

—Time base coordination

—Preemption.

- Terminologies other than those listed may be used provided they are readily identifiable to the user. Connection of the controller to the printer shall be accomplished through the use of a cable with a DB-25 male connector on one end for connection to the printer and the appropriate connector on the other end for connection to the controller auxiliary connector. The Contractor shall furnish two cables to the Department unless otherwise indicated on the plans. Messages shall be displayed on the LCD indicating when printing is completed and when there is an error in transmission.
- Controllers shall have internal traffic-adjusted system coordination (hardwire), non-interconnected system coordination (time base), and preemption. Coordination commands shall be accepted and responded to by the controllers regardless of the phasing used. Controllers shall have coordination outputs to allow its use as a master controller transmitting coordination commands based upon time of day.

Coordination:

- Coordination shall provide for at least four cycle lengths, three offsets per cycle plan, three splits per cycle plan, three permissive periods per split plan, eight force-offs per split plan, and remote flash operation. Shortway smoothing routine shall be provided to smooth coordination plan cycle and offset changes.
- Traffic-adjusted system coordination shall be designed to operate with an impulse through an interconnect cable from a master controller.
- Non-interconnected system coordination shall be designed for coordination of signals based upon time of day and without the use of interconnect cable.

In addition to the coordination requirements, minimum program functions shall conform to one of the following two types:

Type 1	Type 2
150 event times	180 event times
150 time of day functions	48 time of day functions
10 day programs	7 day week program
8 week programs	99 exceptions to the week program
1 year program	synch reference by time and event
10 unique exceptions to the year program	3 auxiliary outputs
synch reference by time and event	Max II selection
3 auxiliary outputs	Phase reversal
Max II selection	
Phase reversal	

Definitions:

- An event time is an hour, minute, and second of a 24-hour day. A time of day function can occur at any of these times.
- A time of day function is a selection of a coordination plan condition or the time switching of an output.
- A day program is a list of the time of day functions for the day. These events specify which coordination plan conditions are selected and which outputs switch during the day.
- A week program specifies which day program shall be used on each day of the week.
- A year program specifies which week program shall be used during each week of the year.
- An exception to the year program causes a day program different from that in the year program to be used on a specific day.

Preemption:

Internal preemption shall provide at least one railroad preemption plan and four emergency vehicle preemption plans that will interrupt the normal operation of the controller upon actuation and initiate a special sequence of operation as shown on the plans. Preemption operation shall be programmable to proceed sequentially through the preemption intervals and hold at the end of a specified interval. Intervals in the preemption plan during which normal cyclic operations resume shall be programmable. Priority of preemption plans shall be programmable or shall be fixed based upon the plan number.

Activation of railroad preemption during the timing of an emergency vehicle preemption will cause the emergency vehicle preemption to clear immediately through normal clearance intervals and initiation of the railroad preemption. Railroad preemption shall be displayed for the duration of the preemption call.

Emergency vehicle preemption timings shall be programmable from at least 0 to 99 seconds. The capability of a delay between the time the emergency vehicle preemption plan input is asserted and the implementation of the preemption plan shall be provided. The timing range for this delay shall be at least 0 to 99 seconds. Emergency vehicle preemption inputs shall be capable of operating in lock and non-lock modes. When programmed non-lock, termination of the input prior to implementation of the preemption plan shall not initiate preemption operation.

Controllers shall be programmed for all required functions through a menu driven keyboard and a LCD except for the following, which may be programmed with dip switches or a combination of keyboard and dip switches.

- Phasing other than NEMA standard dual ring concurrent.
- Phase reversals.
- Security code on and off.

- Startup signal display indication.

The LCD shall be capable of displaying at least four lines of 20 characters each. The LCD shall have backlighting and automatically adjusted or selectable contrast levels for optimum viewing.

Backlighting shall be automatically extinguished within 1 hour after the last keyboard operation. A main menu and submenus shall be provided on the LCD that lists categories in the English language from which the user may select. Entering of data outside allowable timing ranges shall result in the controller rejecting the data. Controllers shall have circuitry for monitoring the cycling of the microprocessor. Upon determination that the microprocessor is not cycling, this circuitry shall automatically cause the intersection to be placed in flashing operation. Active status indications of controller, coordination, and preemption features and timings shall be displayed on the LCD using alphanumeric characters. In addition to the indications required by NEMA, the following indications shall be displayed:

- **Controller status:**

- Time and date
- Overlaps in service
- Interval timings
- Stop time applied
- Phase omit active
- Ped omit active
- Recall type
- Variable initial timing
- Time before reduction timing
- Gap time
- Last car passage active.

- **Coordination status:**

- Command source, e.g., manual, telemetry, time base coordination, interconnect, free or flash
- Cycle, split, and offset number active
- Cycle length
- Offset time

- Local cycle timing
 - Master cycle timing
 - Offset seeking indication
 - Telemetry and interconnect failure indications
 - Vehicle permissive period active
 - Ped permissive period active
 - Hold active
 - Auxiliary output circuit number active.
- **Preemption status:**
 - Preemption number active
 - Preemption interval
 - Preemption timing.

Real-time clock:

Controllers shall have an internal 99-year real-time clock referenced to the 60-Hz AC power line. The clock shall be easily set to the nearest second of the year. A crystal oscillator shall be provided to maintain clock accuracy to at least 0.005 percent (50 PPM) when on standby power. Clock time and date shall be maintained for at least 60 days during periods of power loss. If clock standby power is exhausted during a line voltage power failure, time base coordination shall be prevented from operation. Automatic corrections shall be made for Daylight Saving Time.

Data entered by the controller user except for time and date shall be maintained during power outages through the use of an Electrically Erasable Programmable Read Only Memory (EEPROM).

Unless otherwise specified, the controllers shall be furnished to operate initially as follows:

- Single Entry.
 - Start in Major Street through phase green interval.
- (b) **Flashers for Operating Flashing Beacons:** Flashers shall be solid state, double circuit, and shall be furnished complete in a weatherproof cabinet. The cabinet shall be fabricated of welded sheet aluminum at least 0.125 inch in thickness.

The cabinet shall have transient protection conforming to the requirements of (d)3.b. herein for field wiring, a door gasket, and a standard police panel lock with two keys. A radio frequency interference filter rated at 20 amps, terminal block, and a 20-amp circuit breaker

shall be mounted in the cabinet. The cabinet shall be provided with removable hub plates tapped for 1-inch conduit at the top and bottom and shall be equipped with brackets for wood-pole mounting or with adjustable bands for steel-pole mounting as specified on the plans.

- (c) **Master Controller:** Master controllers shall be solid-state, digital, traffic-adjusted controllers adaptable to fully actuated local controllers. They shall provide for at least three cycle lengths, three independent offsets per cycle, and free operation and shall be capable of volume-density computations. Master controllers shall be from the same manufacturer as the local controllers furnished by the Contractor.
- (d) **Cabinets:** Cabinets for traffic signal controllers and master controllers shall be weather-proof and constructed of welded sheet aluminum, 0.125-inch minimum. Cabinet mounting attachments shall be durable, corrosion resistant, and of heavy-duty construction.

Cabinets shall be at least 54 inches in height, 44 inches in width, and 24 inches in depth and shall be large enough to provide for ease of maintenance of the controller and auxiliary equipment. The maximum width and depth shall be such that the cabinet will fit entirely on the standard CF-1 foundation. The cabinet bolt pattern shall be rectangular, with dimensions of 40 5/8 inches in width and 18 1/2 inches in depth. Anchor bolts shall be 3/4 inch in diameter and at least 16 inches in length with a 5-inch L bend.

1. **Doors:** Cabinet doors shall provide full access to the cabinet interior and shall have gaskets to ensure weatherproofing. A small recessed police panel with a separate access door shall be provided in the front door of the cabinet. The main door shall be equipped with the Department's standard tumbler lock No. 9R48773 or the municipality's standard tumbler lock and shall be keyed. The police panel shall be provided with a standard police panel lock. Two keys for each lock shall be provided the Engineer. Hinges shall be stainless steel and continuous. The main door shall have a door stop arrangement that will allow it to be firmly positioned at both 90 and 135 degrees, ± 10 degrees. The locking mechanism for cabinets shall be a three-point draw roller system. Rollers shall be fabricated from nylon with a diameter of at least 8/10 inch. The door opening shall be double flanged on all four sides.

A panel shall be mounted on the inside of the main door of the master controller cabinet and shall consist of the following four functional switches: auto-manual, manual cycle selector (three cycles), manual offset selector (three offsets), and manual synch.

2. **Police panel:** The police panel shall be furnished with two toggle switches, each labeled for its purpose. One switch will be used to place the signal in flashing operation and shall not affect the power being supplied to the controller and conflict monitor. The cyclic operation of the controller shall not be affected by this switch. Upon placement of the switch from the automatic position to the flash position, the intersection shall immediately be placed in flashing operation. Upon placement of the switch from the flash position to the automatic position, the signals shall immediately be placed in automatic operation in the major street through phase green interval. The second switch shall be used to disconnect power to the controller. The backside of the police panel shall have an aluminum cover over the switches and their wiring connections. When required by the plans, a third toggle switch with a handle control shall be furnished that will allow manual operation of controller phasing.

3. **Interior:** The interior of cabinets shall be of sufficient size to provide adequate ventilation of the equipment housed therein. Cabinets shall contain at least three adjustable shelves or equivalent supports with enough space to hold the controller, 20 single-channel detector amplifiers, and required auxiliary equipment. Vertical mounting channels for the shelves shall be continuous and shall allow for adjustable shelf placement ranging 5 inches from the bottom to 5 inches from the top of the cabinet. Wiring panels (terminal blocks) shall be neatly finished and clearly and permanently marked with identifications applied by silk screening. Conductors shall be neatly arranged in the cabinets and bundled in groups with cable ties. Conductors running to panels other than the resistor panel on the left side of the cabinet shall be positioned below the resistor panel with the nearest conductor being at least three inches from the bottom resistor position. Conductors connected to terminals located on the door shall be bundled and sheathed. The bundled conductors shall not obstruct access to other circuits and terminals in the cabinet. The controller equipment and terminals shall be arranged within the cabinet so that they will not interfere with the entrance, tracing, and connection of conductors. Unless cable is passing through the cabinet uninterrupted, incoming and outgoing conductors shall have each wire connected to terminal post positions.

Cabinets shall be wired in accordance with Section 10 of NEMA TS-1 for NEMA configuration 8 and the changes and additions noted herein. The cabinet shall also be wired to produce controller pin connector functions, including those on auxiliary connectors. Wiring that is connected to the back panel shall be of adequate length to allow the back panel to be placed in position for maintenance.

When exclusive/permissive left-turn phasing is being used, the red output from the load switch for the left-turn phase shall be connected to ground through a 1.5K-ohm resistor. The resistor shall conform to the requirements of MIL-R18546D, Type RE70G1501. Heat sink compound shall be applied to the housing base prior to attachment. Wiring shall be soldered to the resistors and the connections shall then be covered with heat shrink tubing. On unused phases, red outputs shall be wired to AC+. Wiring shall be readily accessible and shall not require the back panel to be lowered for disconnection of the wiring.

Cabinet wiring shall be provided for railroad preemption whereby the selection of the following is easily accomplished through the use of simple hand tools: (1) 115 VAC or ground true outputs, and (2) normally open or normally closed contacts.

The Contractor shall provide five blue and white prints of the controller circuit diagram. The blue and white prints shall be produced from the original drawing and shall be clear and legible. The Contractor shall install two copies of the circuit diagram inside the cabinet in a readily accessible waterproof enclosure and shall furnish three additional copies to the Engineer. The waterproof enclosure shall be securely attached to the cabinet with studs welded to the cabinet and nuts. The enclosure shall have noncorrosive metal grommets for use with the studs.

A listing indicating terminal numbers with a description of their use shall be attached to the cabinet door and overlaid with a clear, plastic covering. Edges of the plastic shall be sealed with a clear waterproofing compound.

Detector harness cables shall be stranded copper and shall be not sized less than No. 22 AWG rated at 300 volts. Other AC and DC circuit wiring shall be in accordance with

NEMA TS-1. Ribbon cable and printed circuit boards will not be allowed for cabinet wiring. Loop detector harnesses shall include wires connected to the two reserved pins in the connector. At the end of the harnesses, these wires shall be folded back and tied to the harnesses with nylon cable ties. Loop input wiring in the loop detector harnesses shall have soldered on spade connectors for attachment to the detector panel terminals. Heat shrink tubing shall be installed over the soldered connections.

Controller cabinets shall be wired to provide output signals for the controller to the loop detector amplifiers so that the delay feature of the associated phase is inhibited during the green interval.

Outgoing traffic signal circuits shall be the same polarity as the line side of the power supply. The common return of signal circuits shall be the same polarity as the ground side of the power supply. The power supply shall be grounded to the ground bus of the controller cabinet. The ground bus, neutral bus, and logic ground bus in the cabinet shall be copper.

When the time-based coordination feature of the controller is used to establish a coordinated system with controllers operating fully actuated, the controller cabinet shall be wired to inhibit mainline through, right turn, and pedestrian detectors when coordination is not in free operation.

Transient protection shall be provided in traffic signal controller and master controller cabinets for the following:

- a. **Main AC power input:** Transient protection for the AC power input shall be connected on the load side of the main AC circuit breaker. The transient protection shall (1) withstand a 15,000-ampere surge current with an 8 by 20 microsecond wave form, 20 times at 3-minute intervals between surges, without damage to the suppressor; (2) limit the surge voltage to a 2,000-volt peak; and (3) limit follow current to an appropriate level to prevent tripping of the main circuit breaker of the cabinet or enclosure.
- b. **Interconnect cable and field wiring:** Transient suppression for field wiring shall be installed on the front of the back panel. Transient suppression for interconnect cable and field wiring, except loop detector lead-in cable, shall (1) clamp the surge voltage to a level no greater than twice the peak operating voltage of the circuit being protected and (2) withstand a surge current of 1,000 amperes with an 8 by 20-microsecond wave form, six times at 1-second intervals between surges, without damage to the suppressor.
- c. **Loop detector lead-in cable:** The panel shall be located on the right side near the front of the cabinet and above the level of the lowest shelf. A preemption test switch with necessary wiring shall be located on this panel. Transient suppression for loop detector lead-in cables shall not affect the operation of inductive vehicle loop detectors and shall (1) protect detector unit loop inputs against differential (between the loop lead) surges and against common mode (between loop leads and ground) surges, (2) clamp the surge voltage to 25 volts or less when subjected to repetitive 300-ampere surges, and (3) withstand repetitive 400-ampere surges with an 8 by 20-microsecond wave form without damage to the suppressor.

4. **Accessory and auxiliary equipment:** As a minimum, traffic signal controller cabinets shall be furnished with the following:
- a. Removable, noncorrosive metal back panel (13-gage minimum) that shall incorporate a swing-down design to allow it to be placed in at least a 60-degree angle below the vertical position when the top attachment mechanisms are removed. The design shall use noncorrosive metal hinges or pins of adequate number and strength to support the back panel and attached equipment.
 - b. Removable, noncorrosive metal detector panel (13-gage minimum) at least 35 inches in length and 6 1/2 inches in width with two rows of barrier terminal blocks. Each row shall consist of 48 double-pole terminals rated at 4,000 volts r.m.s., 30 amps, and be able to accommodate up to 10-gage solid wire. The panel shall be wired in accordance with the following:
 - (1) 16 double-pole terminals for vehicle calls (2 per phase)
 - (2) 4 double-pole terminals for pedestrian calls (1 each for phase 2, 4, 6, and 8)
 - (3) 3 double-pole terminals for detector +115 VAC
 - (4) 3 double-pole terminals for detector AC Common
 - (5) 3 double-pole terminals for ground
 - (6) 3 double-pole terminals for detector logic ground
 - (7) 8 double-pole terminals for 115 VAC delay override
 - (8) 4 double-pole terminals each for phase 1, 3, 5, and 7 for vehicular detector field wiring
 - (9) 10 double-pole terminals each for phase 2, 4, 6, and 8 for vehicular detector field wiring.
 - c. Removable, noncorrosive metal auxiliary panel(s) (13-gage minimum) with terminals wired for auxiliary connector(s) functions
 - d. Removable, noncorrosive metal detector test panel (13-gage minimum), readily accessible when the main cabinet door is opened, providing vehicle inputs through a momentary switch to each of the 8 phases and pedestrian inputs to phases 2, 4, 6, and 8.
 - e. Ground fault convenience receptacle.
 - f. Removable, noncorrosive metal power panel (13-gage minimum) located on the right side near the front of the cabinet. A clear Plexiglass shield with openings for manual operation of breakers shall be installed over the panel with standoffs and thumbscrews.

- g. Two circuit breakers. One circuit breaker, which shall be isolated from the power supply for the signal and control equipment, shall be rated at least 20 amps and shall operate the vent fan, ground fault convenience receptacle, and lamp. The second circuit breaker shall be rated at least 20 amps or as required by the loading and shall operate all other equipment, including the signal load. Separate terminal strips shall be provided for each circuit breaker and an unfused terminal for the neutral side of the power supply line.
- h. Screened and louvered vent designed to prevent rain entry, with a 14 by 20 by 1-inch standard furnace vent filter. The filter tray shall be sized to house and secure the filter in place. The screen shall be constructed from at least 0.031-inch aluminum with 1/8-inch diameter openings positioned on 3/16-inch staggered centers. The screen shall be placed on the inlet side of the filter and held in place by the filter or silicone adhesive.
- i. Screened air exhaust opening under the top overhang.
- j. Thermostatically controlled vent fan with a screened guard in the top section of the cabinet with a capability of exhausting at least 100 CFM. The thermostat shall be adjustable from 80 degrees F to 130 degrees F. Degree markings shall be indicated on the thermostat in 10-degree increments.
- k. Radio frequency interference filter rated at 50 amps.
- l. Transient protection devices.
- m. Dual-circuit flasher, 15 amp rating over the temperature range of -34 degrees C to +74 degrees C conforming to NEMA standards with an LED indicator for each circuit.
- n. Fluorescent lamp, ordering code #F20T12/D, and an on/off door switch located in the cabinet so that it will provide for the unobstructed illumination of controller timing adjustments. A toggle switch mounted on the cover behind the police panel, and a momentary switch operated by the door shall be connected in-line for operation of the lamp.
- o. Twelve-channel NEMA stand-alone conflict monitor with its own power supply and an LCD. The monitor shall have an internal 99-year real-time clock referenced to 60 Hz AC power line. Clock shall be easily set to the nearest second of the year from the front panel. A crystal oscillator shall be provided to maintain the accuracy of the clock to at least 0.005 percent (50PPM) when on standby power. Clock time and date shall be maintained for at least one year during periods of power loss. Automatic corrections shall be made for Daylight Saving Time.

In addition to NEMA requirements, the conflict monitor shall have user-selectable features for monitoring simultaneous dual indications on a channel and controller amber clearance intervals. The intersection shall be placed in flashing operation if the controller amber clearance interval is less than a fixed minimum and when programmed dual indications occur simultaneously on a channel. If power loss occurs after a failure, the conflict monitor shall be capable of displaying, upon restoration of power, the indications on at the time of power loss. The conflict

monitor shall log at least nine previous faults and 10 power interruptions and restoration by date and time in non-volatile memory.

Conflict monitor shall have an auxiliary connector mounted on the front panel that will allow transfer of data to a printer. Connection of the conflict monitor to the printer shall be accomplished through the use of a cable with a DB-25 male connector on one end for connection to the printer and the appropriate connector on the other end for connection to the conflict monitor auxiliary connector. The Contractor shall furnish two cables to the Engineer Upon command, current date and time, monitor configuration, and previous faults and power interruptions and restorations shall be printed in a usable format without disrupting normal monitor operation. Previous faults shall indicate channel indications on and time and date of fault occurrence.

The LCD shall have display indications in conformance with NEMA and the following changes and additions:

- (1) Four individual indications per channel displaying active red, yellow, green, and walk inputs. Indications shall be displayed using the following symbology: R = red, Y = yellow, G = green, and W = walk. The monitor shall be capable of displaying the indications simultaneously for all active inputs.
 - (2) Amber clearance failure indication.
 - (3) Dual indication.
 - (4) Program card compatibility phases.
 - (5) Date, time, and type of fault condition including channel indications on for logged faults.
 - (6) Date and time for power interruptions and restorations.
 - (7) Current date and time.
- p. Wired signal, pedestrian, and overlap load switch mounting bases (16) wired for the following from left to right: 8 phases, 4 overlaps, and pedestrian movement for phases 2, 4, 6, and 8.
- q. Twelve solid-state signal load switches (signal and overlap) conforming to NEMA standards, each having LED indicators for active input and output circuits. The load switch shall have a 15-amp rating over the temperature range of -34 degrees C to +74 degrees C.
- r. Six flash-transfer relays with a rating of 1/4 H.P. at 120 VAC; 30 AMP, 120/240 VAC; 20 AMP, 28 VDC.
- s. One or more field wiring terminal(s) for each light circuit plus one terminal for the common conductors but not fewer than one for every four signal circuits. Signal common terminals shall be grounded to the cabinet.

- t. Two switches inside the main cabinet on the cover behind the police panel that provide the same functions as the switches in the police panel.
 - u. Removable, noncorrosive metal resistor panel (13-gage minimum) located on the left side near the bottom of the cabinet. The panel shall be of sufficient size to mount four resistors adequately. Resistors shall be mounted horizontally, one below the other, in the following order from top to bottom: phase 1, phase 3, phase 5 and phase 7.
- (e) **Signal Heads:** Signal head sections used in installing intersection control beacons and hazard identification beacons shall be the same as those described herein for standard traffic signal head sections.

Cast aluminum signal head sections shall be used for span wire installations, free-swinging mast arm installations, and pedestal-mounted installations that use only slipfitters. Cast aluminum or polycarbonate signal head sections may be used for all other installations.

1. **Traffic signal lamp wattages** shall be as follows: 60-watt lamps for 8-inch amber flashers, 100-watt lamps for all other 8-inch sections, 100-watt lamps for 12-inch amber flashers, and 150-watt lamps for all other 12-inch sections.
2. **Traffic signal backplates** shall be specifically manufactured for the type and brand of signal heads used to ensure proper fit with a border width of 5 inches and shall be without louvers and of one-piece construction with the exception of those for five-section cluster signal heads, which may be a maximum of five pieces.
3. **Standard traffic signal head sections** shall conform to the requirements of the ITE Standard for Vehicle Traffic Control Signal Heads and Section 238 and shall include cap visors.
4. **Selective view traffic signal head sections** shall conform to the requirements of Section 238, shall permit the visibility zone of the indication to be determined optically, and shall not require hoods or louvers. The projected indication shall be selectively visible or veiled within 15 degrees of the optical axis. No indication shall result from external illumination, and one light unit shall not illuminate another unit.

The optical system and materials shall be composed of a lamp with a collar, an optical limiter-diffuser, and an objective lens. The lamp shall be a three-pronged sealed beam having an integral reflector with stippled cover and shall be coupled to the diffusing element with a collar that includes a specular inner surface. The diffusing element shall be discrete or integral with the convex surface of the optical limiter.

The optical limiter shall provide an accessible imaging surface at focus on the optical axis for objects 900 to 1,200 feet away and shall permit an effective veiling mast to be variously applied as determined by the desired visibility zone. The optical limiter shall be provided with a means for positive indexing and shall be composed of heat-resistant glass.

The objective lens shall be a high-resolution annular incremental lens hermetically sealed within a flat laminant of weather-resistant acrylic or an approved equal. The lens

shall be symmetrical in outline and capable of being rotated to any 90-degree orientation about the optical axis without displacing the primary image.

The optical system shall accommodate the projection of diverse, selected indications to separate portions of the roadway such that only one indication will be simultaneously apparent to any viewer. The projected indication shall conform to ITE transmittance and chromaticity standards.

Die-cast aluminum parts shall have a chromate preparatory treatment. The exterior of the signal case, lamp housing, and mounting flanges shall be finished with high-quality baked enamel primer and finish paint. The lens holders and interior of the case shall be optical black.

The signal case and lens holders shall be predrilled for backplates and visors. Hinge and latch pins shall be stainless steel. Access openings shall be sealed with weather-resistant rubber gaskets.

The signal shall mount to a standard 1 1/2-inch traffic signal fitting as a single section, a multiple section face, or in combination with other signals. The signal section shall be provided with an adjustable connection that permits incremental tilting from 0 to 10 degrees above or below the horizontal plane while maintaining a common vertical axis through the couplers and mounting. The terminal connection shall permit external adjustment about the mounting axis in 5-degree increments. The signal shall be mountable with ordinary tools and capable of being serviced with no tools.

Attachments, such as visors, backplates, and adapters, shall conform and readily fasten to existing mounting surfaces without affecting the water and light integrity of the signal.

Lamp fixtures shall be composed of a separately accessible housing and integral lamp support; an indexed ceramic socket; and a self-aligning, quick-release lamp retainer. Electrical connection between the case and lamp housing shall be accomplished with an interlock assembly that disconnects the lamp holder when opened. Each signal section shall include a covered terminal block for clip or screw attachment of lead wires. Concealed No. 18 AWG stranded and coded wires shall interconnect sections to permit field connection within any section.

Each signal section shall include an integral means of regulating its intensity between limits as a function of individual background illumination. Lamp intensity shall be at least 97 percent of the uncontrolled intensity at 1,000 footcandles and shall decrease to 15 ± 2 percent of maximum at less than 1 footcandle. Response shall be essentially instantaneous and proportional to any detectable increase in illumination from darkness to 1,000 footcandles and damped for any decrease from 1,000 footcandles.

The intensity controller shall be composed of an integrated directional light sensing and regulating device interposed between the lamp and wires. It shall be compatible with a 60-Hz input and responsive within the range of 105 to 135 volts. Output may be phase controlled, but the device shall provide a nominal terminal impedance of 1,200 ohms open circuit and a corresponding holding current.

The signal head shall be optically programmed in accordance with the manufacturer's recommendations.

5. **Pedestrian signal heads** shall conform to the requirements of ITE Standards for Pedestrian Traffic Control Signal Indications and Section 238.
 6. **Lane-use control signal heads** shall conform to the requirements of ITE Standards for Lane-Use Traffic Control Signal Heads and Section 238.
- (f) **Illuminated Traffic Control Signs:** Signs shall be square or rectangular weatherproof units. Only internal illumination shall be used. When illuminated, the message shall be white on an opaque background. The sign face or cover shall consist of a polycarbonate lens. The housing shall be sheet aluminum at least 0.125 inch in thickness finished with two coats of flat black paint.

The size and arrangement of letters forming the message shall conform to the requirements of the *Federal Standard Highway Signs Booklet* or an adaptation approved by the Engineer. When activated, the message shall be clearly readable at all times at a distance of 200 feet in all atmospheric conditions except dense fog. The message shall be controlled by a time clock or another type of actuation as specified on the plans. Signs shall illuminate instantly without a "warm-up" requirement or a continuously energized ballast. When signs are de-energized, the message shall not be readable.

(g) **Detectors:**

1. **Magnetic detectors** shall consist of a sensitive magnetic circuit housed in a light-weight metal cylinder approximately 2 inches in diameter, approximately 20 inches in length, and shall be equipped with two 35-foot (minimum) stranded leads.
2. **Magnetic detector amplifiers** shall be solid-state and properly connected to sensor(s) to produce, upon vehicle actuation, an output through a relay that has both normally closed and normally open circuits. A fail-safe design shall be incorporated so that a constant detection signal for control equipment will be provided in the event of a power loss. The unit shall be housed in a mechanically sound metal enclosure designed to allow stacking of multiple units having maximum dimensions of 3 inches in height, 6 inches in width, and 8 inches in depth. An 8-pin MS connector for making external detector connections, an adjustable sensitivity control, and a visual vehicle actuation indicator shall be provided on the front panel of the amplifier enclosure. The amplifier shall provide stable operation within an ambient temperature range of -30 degrees F to +135 degrees F when operating from a 120-volt, 60-Hz, single-phase AC power supply with a nominal power consumption of 5 watts or less. A fuse of a suitable ampere rating shall be provided to protect the power supply of the detector amplifier. Fuses shall be easily replaceable from the front panel.
3. **Inductive loop detectors** shall conform to the requirements of the performance characteristics required by NEMA TS-1.

The manufacturer of the loop detector amplifier shall provide a certification from an independent testing laboratory that the model furnished complies with NEMA Environmental Standards and Test Procedures.

Loop detector amplifiers shall be a single-channel, shelf-mounted, relay-output type with indicator lights on the front panel and delay and extension detection features. When the delay feature is used, it shall be inhibited during the green interval of its associated phase. The detector amplifier shall be adequately fused, and fuses shall be easily replaceable from the front panel.

4. **Pedestrian detectors** shall be pushbutton operated at low voltage (not more than 15 volts AC or 24 volts DC).

703.03—Procedures

Equipment shall be installed so that it is ready for full operation.

- (a) **Prosecution of Work:** The Contractor shall not discontinue the operation of an existing signal without the approval of the Engineer. Requests for discontinuance shall be made at least 48 hours in advance.

While modifying or replacing existing traffic signals, the Contractor shall provide necessary traffic controls for maintenance of traffic, as approved by the Engineer. Traffic flow shall be maintained during the modification or replacement. Normal or routine maintenance that is not attributable to the Contractor's operations will remain the responsibility of the Department or local municipality.

When the Contractor begins modifying or replacing existing signal equipment or placing new signal equipment in operation, he shall maintain and repair the equipment until final acceptance. If the equipment malfunctions during the Contractor's working hours or during peak traffic hours as determined by the Engineer, the Contractor shall take immediate action to maintain the normal flow of traffic and make necessary repairs as expeditiously as possible that will cause the least interference with traffic.

The Contractor shall furnish the Engineer with the name and telephone number of the supervisory employee of his company who will be responsible for responding to repair calls during nonworking hours. If a signal malfunctions, the Contractor shall make necessary repairs within 4 hours from the time of notification. If the Contractor fails to make the repairs within 4 hours, the Department may make the repairs in accordance with the requirements of Section 104. This shall in no way relieve the Contractor of his responsibility for maintaining and completing the work.

When replacing or modifying an existing coordinated signal system, the Contractor is not required to maintain the existing system coordination unless directed to do so by the Engineer.

- (b) **Equipment Color:** The color of metal equipment shall be obtained by applying two coats of paint. The color of plastic equipment shall be obtained by impregnating the color into the plastic. When painting of aluminum and galvanized metal equipment is required, the equipment surface shall be treated to ensure adherence of the paint. Signal head color shall be Federal Yellow except that the inside of the visors shall be flat black. Backplates (both sides) and signal leveling attachments shall be flat black.

- (c) **Refurbishing Existing Equipment:** Existing equipment to be retained shall be cleaned. Existing metal equipment to be retained shall be repainted as specified herein.
- (d) **Mounting Controller Cabinets:** Pole-mounted controller cabinets shall be attached to metal poles or signal pedestals by means of brackets secured by encircling clamps made for the purpose and to wood poles by means of lag screws and plates bolted through the back of the cabinet or by encircling clamps made for the purpose.

Ground-mounted cabinets shall be installed on a concrete foundation.

- (e) **Installing Signal Heads:** At new or modified traffic signal installations, each signal head shall be covered with a durable, nontransparent cover upon installation. The Contractor shall maintain the cover until the signal is put into operation.

Housings shall be joined at the top and bottom in accordance with the manufacturer's specifications to form complete signals. Unused ends of sockets shall be closed with ornamental cap screws. Joints shall be rendered weatherproof by a suitable combination of lead and steel washers.

1. **Standard and selective view traffic signal heads** shall be installed so that there is at least 8 feet between lines drawn perpendicular to the center of any two adjacent signal heads that provide indications to the same approach. The Contractor shall verify the location and alignment of each signal head for orientation to its approach lane(s) prior to installing the signal conductor cable. If the location of the signal head designated on the plans is not oriented correctly with the applicable approach lane(s), the Contractor shall determine the proper location(s) and submit supportive data to the Engineer for review.

The bottom of the housing of a pedestal-mounted or bracket-mounted signal face adjacent to the pavement shall be at least 8 but not more than 15 feet above the sidewalk or, in the absence of a sidewalk, above the pavement grade at the center of the roadway.

Balance adjusters shall be installed with span wire hanger assemblies. Lock washers shall be used with nuts on the balance adjuster, and the vertical eyelet bolt shall have a cotter key inserted through a hole in the center of the bolt. The hole shall be located approximately two threads from the bottom of the bolt. The vertical eyelet bolt shall be secured from movement with a lock nut.

Serrated teeth on hanger assemblies shall be of the correct number and size to mate properly with the teeth on the signal heads.

The lowest point of the signal head assembly, including backplates and tether wire attachments, suspended over the roadway shall be at least 15 feet for mast arm installations and at least 16 feet for span wire installations above the pavement grade at the center of the roadway. The bottom of the signal head housing shall be not more than 19 feet above the pavement grade at the center of the roadway for mast arm and span wire installations.

2. **Pedestrian signal heads** shall be mounted with the bottom of the lower signal unit at least 7 but not more than 10 feet above the sidewalk and shall be placed in the line of

vision of pedestrians using the applicable crosswalk. When mounted on the same support with vehicular signal indications, signal groupings shall be at least 1 foot apart. Pedestrian indications shall be below vehicular indications.

3. **Lane-use control signal heads** shall be installed to operate in accordance with the *MUTCD*. The lowest point of the signal head assembly suspended above the roadway shall be in accordance with (e)1. herein.
 4. **Signal lamps** shall be installed in signal heads in accordance with the ITE Standard for Vehicle Traffic Control Signal Heads.
 5. **Backplates** shall be attached with bolts, washers, and lock nuts or self-tapping screws and washers. The number of bolts or self-tapping screws required shall be at least 8 for a three-section signal head assembly, 10 for a four-section assembly, and 12 for a five-section assembly. Bolts, screws, and washers shall be of a noncorrosive metal or shall have a noncorrosive outside coating.
- (f) **Installing Illuminated Traffic Control Signs:** Illuminated signs used to control right or left turns shall be mounted directly over or adjacent to the affected traffic lane(s) at the height prescribed for standard traffic signals. When mounted with standard and selective view traffic signal indications, illuminated traffic control signs and signals shall be separated so as to prohibit physical contact.
- (g) **Installing Detectors:** The location of detectors shall not deviate more than ± 2 feet from the location(s) shown on the plans unless the Contractor submits a detailed drawing showing the exact location of the detector(s) in question and secures the written approval of the Engineer. Detector lead-in cable shall be continuous and unspliced from the detector to the detector panel terminals.

Splices between loop or magnetic detector conductors and the lead-in conductors shall be allowed only in signal junction boxes. A separate splice kit shall be used for each lead-in cable. These splices shall be joined, made mechanically secure, and then tested electrically. When the mechanical connection has been shown to be electrically functional under operational conditions, it shall be soldered with a fusible metal or alloy. Each splice shall then be covered with one layer of half-lapped, 3/4-inch self-bonding rubber tape and one layer of half-lapped, 3/4-inch vinyl tape. The tape shall be installed so at least 3/4 inch of the insulation is covered by the tape. The splice shall then be installed in a splice kit.

Detector and detector lead-in cable shall be installed with the slack length coiled in the junction boxes. The coiled length shall be sufficient to allow the cables to extend at least 2 feet above the junction boxes.

Detector and detector lead-in cable jackets shall be permanently identified in the controller cabinet and junction boxes. Identifications shall be indicated on nonferrous metal tags or nylon tags attached to the cable with nylon cable ties. The identification shall be stamped or engraved on the metal tags and lettered with permanent ink on nylon tags. Identifications shall be legible and shall conform to the following:

- **Detector lead-in cable:** phase and location (lane and setback distance from stop line) of detector: e.g., 1 NB stop line left-turn lane loop 2 SB 200 feet through lanes mag.; 6 NB stop line inside through-lane loop; 2 Ped NW Quad.

- **Detector cable:** phase and location of detector: e.g., 1 NB left-turn lane loop; 2 SB through-lane mag.; 6 NB inside through-lane loop; 6 NB outside through-lane loop.

1. **Magnetic detectors:** Magnetic detectors shall be encased in heavy-wall PVC conduit 3 inches in diameter installed in a trench cut to a depth of 15 inches and shall be surrounded with at least 3 inches of sand. When approved by the Engineer, the sensing element, encased in PVC conduit, may be installed in a hole bored parallel to the surface and at the required depth.

Magnetic detector circuits shall not be run in the same cable sheath with conductors carrying signal power.

2. **Inductive loop detectors:** Slots shall be sawed into the pavement, cleaned with pressurized water at a minimum of 50 pounds per square inch, and then dried with filtered compressed air before loop conductors are installed and sealed. One-inch lengths of PE foam backer rod shall be installed in the slot at slot intersection points and on 2-foot-maximum centers between those points after installation of the loop conductors. The backer rod diameter shall be 1/2 inch for 3/8-inch slots, 5/8 inch for 1/2-inch slots, and 3/4 inch for 5/8-inch slots. Sealant shall conform to the requirements of Section 212. Loops shall be installed in the presence of the Engineer.

Loop detectors shall not be installed in pavement that has been open cut, repaired, or rebuilt in a manner where the pavement structure is not sound and continuous in the area of the proposed loop installation. When loop detectors are to be installed in existing pavement, the Contractor shall first field inspect the loop locations and advise the Engineer of any such locations that have been open cut, repaired, or rebuilt. The Engineer will direct the Contractor in locating the loop detectors.

A Megger reading of at least 100M ohms shall be obtained for each loop detector (cable and shield). This test shall be made at 500 volts immediately before the sealant is installed and again after the sealant has set at least 24 hours. Cable shall be disconnected from the detector amplifier during testing.

Loop cable shall be installed without damaging the cable or its insulation. Damaged cables shall be replaced at the Contractor's expense. Cable shall be installed with no kinks or curls and no straining or stretching of the insulation and shall be secured as deep in the slot as possible. When loop cable crosses pavement joints, an 8-inch section of flexible plastic sleeve shall be installed to prevent damage from pavement shifts. A blunt object, similar to a wooden paint stirrer, shall be used to seat the loop cable. The two ends of the loop conductor cable between the roadway loop and the junction box shall be twisted together, with approximately two turns per running foot.

The lead-in cable shield (drain wire) shall be connected to ground at the controller cabinet only. The lead-in cables shall have soldered on spade connectors for attachment to the detector panel terminals. Heat shrink tubing shall be installed over the soldered connections.

3. **Pedestrian detectors:** Pedestrian detectors shall be mounted on supports as indicated on the plans. Breakaway connectors shall be installed on conductor cables for pedestrian detectors on pedestal poles. Breakaway connectors shall be fused for the hot con-

ductor and nonfused for the grounded conductor. The location of the breakaway connectors shall be in the hand hole of the pedestal pole.

(h) **Rigging Details:**

1. **Overhead span wire:** Where a 1/4-inch span wire terminates at a wood or steel pole, it shall be attached to a 5/8-inch thimbleye bolt and secured with two 2-bolt clamps. Where a 1/2-inch span wire terminates at a wood or steel pole, it shall be attached to a 3/4-inch thimbleye bolt and secured with two 3-bolt clamps.

Span wires shall be unspliced and unjointed and tightly drawn to the desired height and position while the pole is maintained in the vertical position.

Saddle clamps, strand connectors, and strain insulators shall be designed for the size of the span wire and shall meet or exceed the strength of the span wire.

Down guys shall be used on wood poles and shall be the same type of cable used in span wires. They shall be attached to the pole in the same manner and at the same height as span wires. Lateral guys placed over the roadway shall be strung to maintain a vertical clearance of at least 17 feet 6 inches. Lateral guys and down guys shall be tightly drawn in a manner to secure the pole while its vertical alignment is maintained. Metal or approved plastic gutters shall be installed on down guys. Sidewalk struts shall be provided where the vertical distance from the sidewalk to the down guy is less than 8 feet.

Integral messenger cable may be used for interconnect cable runs in lieu of span wire support. Signals, signs, or other equipment shall not be suspended from integral messenger cable.

Obstructions shall be bypassed by the use of special brackets or pole extensions.

2. **Tether wire:** Tether wire shall be unspliced and unjointed and attached to a pole by means of a 5/8-inch thimbleye bolt, a two-bolt clamp, and a guy sleeve. Tether wire shall be drawn in a manner to secure the attached signal head against movement caused by wind loads. Signals, signs, or other equipment shall not be suspended from tether wire.
- (i) **Testing Equipment:** After energizing the signal installation, the Contractor shall demonstrate to the Engineer that electrical components are in proper working order. Faulty electrical components shall be repaired or replaced by the Contractor at his expense.

Upon completion of electrical tests, the Contractor shall conduct a demonstration test of each signalized intersection for 30 continuous days. The Contractor shall provide personnel to fine-tune and correct deficiencies in traffic signal installation(s) during the 30-day test period at his own expense. If any portion of the signal installation(s) is replaced or repaired, the portion shall be subjected to an additional 30-day test immediately after replacement or repair.

Testing of the traffic signal system master controller and system coordination shall be conducted after completion of the demonstration test of each signalized intersection.

A Phase I test and debugging period of at least four consecutive calendar days shall begin after the system has been installed and approved by the Engineer. The test period shall conclude with a formal successful demonstration of the proper operation of system functions.

Upon successful completion of the Phase I test, the system shall undergo a Phase II operational test of at least 30 days. During this period, the system shall be programmed to provide on-line traffic control. The Phase II test will be considered complete and the system acceptable when all system functions demonstrate full compliance with the specifications. If failures occur, tests shall be stopped. After corrections are made, a new 30-day test shall commence.

Prior to final acceptance, the Contractor shall furnish the Engineer written certification that the system control equipment has been installed in accordance with the manufacturer's specifications.

703.04—Measurement and Payment

Master controllers will be measured in units of each and will be paid for at the contract unit price per each. This price shall include timing data, timing implementation, training, controller cabinets, back panels, power panels, detector panels, auxiliary panels, circuit diagrams, manufacturer's instructions, relays, auxiliary equipment, flexible cables, grounding systems, transient protection devices, radio frequency interference filters, wiring, and fittings.

Controllers will be measured in units of each and will be paid for at the contract unit price per each. This price shall include timing data, timing implementation, training, controller cabinets, back panels, power panels, detector panels, auxiliary panels, police panels, thermostatically controlled fan units in the cabinet with a vent, flashers, local flasher switches, radio frequency interference filters, signal switches, main switches, police hand controls, conflict monitors, flasher relay assemblies, power relays, signal control assemblies, lamp receptacles and ground fault convenience receptacles, circuit diagrams, flexible cables, grounding systems, transient protection devices, and fittings.

Traffic signal head sections will be measured in units of each and will be paid for at the contract unit price per each. This price shall include mountings, molded terminal blocks, visors, backplates, fittings, realignments, lamps, and optical adjustments or LED modules as required.

Pedestrian signal heads will be measured in units of each and will be paid for at the contract unit price per each. This price shall include mountings, LED indication modules, molded terminal blocks, visors, fittings, and realignments.

Detector amplifiers will be measured in units of each and will be paid for at the contract unit price per each. This price shall include connecting cables and fittings.

Magnetic detector sensing elements will be measured in units of each and will be paid for at the contract unit price per each. This price shall include the sensing element with leads, PVC conduit, trenching, backfilling, compacting, boring, sand, and repairing the pavement structure.

Pedestrian pushbuttons will be measured in units of each and will be paid for at the contract unit price per each. This price shall include fittings and sign(s).

Flashers for flashing beacons will be measured in units of each and will be paid for at the contract unit price per each. This price shall include cabinets, mounting hardware, transient protection devices, radio frequency interference filters, power panels, grounding systems, and fittings.

Saw cuts will be measured in linear feet and will be paid for at the contract unit price per linear foot. This price shall include cutting, cleaning, drilling, disposing of surplus material, backer rods, and loop sealant material.

Hanger assemblies will be measured in units of each and will be paid for at the contract unit price per each. This price shall include pipe, brackets, clamps, balance adjusters, tether wire attachments, leveling devices, and fittings.

Illuminated traffic control signs will be measured in units of each and will be paid for at the contract unit price per each. This price shall include enclosure cabinets, sign messages, lens, lamps, internal electrical wiring and components, louvers, mounting attachments, grounding systems, and fittings.

Tether wire will be measured in linear feet from connection point to connection point and will be paid for at the contract unit price per linear foot. This price shall include thimbleye bolt assemblies and fittings.

Span wire will be measured in linear feet, from connection point to connection point, and will be paid for at the contract unit price per linear foot. This price shall include thimbleye bolt assemblies, conductor cable supports, and fittings.

Cable terminal enclosures will be measured in units of each and will be paid for at the contract unit price per each. This price shall include weatherproof enclosures, foundations, terminals, terminal panels or racks, grounding systems, and fittings.

Loop detector cable and lead-in cable will be measured and paid for in accordance with the requirements of Section 700.05.

Cleaning, painting, and grouting of existing equipment retained in signal modifications will not be measured for separate payment but will be considered incidental to other items of work.

Payment will be made under:

Pay Item	Pay Unit
Master controller	Each
Controller	Each
Traffic signal head section (Size and type)	Each
Pedestrian signal head (Standard)	Each
Detector amplifier (Type)	Each
Magnetic detector sensing element (Standard)	Each
Pedestrian pushbutton	Each
Flasher	Each
Saw cut	Linear foot
Hanger assembly (Standard, []-way)	Each
Illuminated traffic control sign	Each
Tether wire (Size)	Linear foot
Span wire (Size)	Linear foot

Pay Item	Pay Unit
Cable terminal enclosure (Standard)	Each

SECTION 704—PAVEMENT MARKINGS AND MARKERS

704.01—Description

This work shall consist of establishing the location of pavement markings and installing pavement markings, pavement markers, and reflectorized material on specified pavements in accordance with these specifications, the *MUTCD*, and as directed by the Engineer.

704.02—Materials

The Contractor shall use an approved inventory tracking system for all materials received from the manufacturer. Shipment of materials from such inventory shall be accompanied by a signed form C-85 containing the following certification statement:

Material shipped under the certification has been tested and approved by VDOT as indicated by laboratory test numbers listed hereon.

- a) **Pavement Markings** shall conform to the requirements of section 246.
- b) **Glass Beads** shall conform to the requirements of section 234.
- c) **Pavement Markers** shall conform to the requirements of section 235.

704.03—Procedures

The Contractor shall have a certified Pavement Marking Technician present during pavement marking operations.

Pavement markings shall be installed on new roadways prior to opening the roadway to traffic. Pavement marking installation shall be completed within the time limits herein on roadways where the pavement markings have been removed or obscured and the roadway is open to traffic unless otherwise directed by the Engineer. Installation of Type B, Class VI, pavement markings on asphalt roadways are not applicable to these requirements if they are inlaid with the last pass of the asphalt roller or directly after the asphalt roller using a separate roller. Installation of edge lines on roadways where the existing pavement markings have been removed or obscured are also required within these time limits unless otherwise indicated by the Engineer. Exceptions to the below time limits will be granted only for weather restrictions, and installation of epoxy resin pavement markings on new pavement shall not commence until after 24 hours of final surface placement.

Pavement marking installation on roads having traffic volumes of 10,000 ADT or more shall be completed within 24 hours after the end of the workday where the pavement markings were removed or obscured.

Pavement marking installation on roads having traffic volumes between 3,000 and 10,000 ADT shall be completed within 48 hours after the end of the workday where the pavement markings were removed or obscured.

Pavement marking installation on roads having traffic volumes of less than 3,000 ADT shall be completed within 72 hours after the end of the workday where the pavement markings were removed or obscured.

If the Contractor will not have pavement markings installed within the time limits specified, the Contractor shall install Type D construction pavement markings within the same time limits and maintain such until the final pavement markings can be installed. The cost of installing, maintaining, and removing the Type D construction pavement markings shall be borne by the Contractor at no cost to the Department.

When establishing the location of pavement markings, the Contractor may mark the locations on the roadway by installing premarkings. Premarkings shall be accomplished using Type D (removable, any class) tape, chalk, or lumber crayons except special pavement markings such as stop lines, crosswalks, messages, hatching, etc., shall be made using chalk or lumber crayons. Premarkings shall be of the same general color as the pavement markings being premarked. When tape is used as premarking, premarking shall consist of 4-inch by 4-inch-maximum squares or 4-inch-maximum diameter circles spaced at 100-foot-minimum intervals in tangent sections and 50-foot-minimum intervals in curved sections. At locations where the pavement marking will switch colors, e.g., gore marking, the ends of the markings may be premarked regardless of the spacing. When chalk or lumber crayon is used as premarking, the entire length of the pavement marking may be premarked. Premarkings shall be installed whereby their installation shall not affect the adhesion of the pavement markings. When Type D tape is used as the premarking and the lateral location of such premarkings to the final pavement markings exceeds 6 inches, the premarkings shall be removed at no cost to the Department.

- (a) **Pavement Markings:** Pavement markings shall be white or yellow markings as required by the *MUTCD* for the specific location or as specified by the Engineer and shall be installed in accordance with Table VII-1 unless otherwise recommended by the manufacturer and approved by the Engineer. The Contractor shall furnish a copy of the manufacturer's installation recommendations to the Engineer.

The Contractor shall perform quality control testing for application thickness and glass bead rate in accordance with VTM-94 at the beginning of each workday and every 3 hours thereafter. The Contractor shall be responsible for providing the apparatus indicated in VTM-94 that are needed to perform the quality control testing. Testing shall be performed in the presence of the Engineer.

The Contractor shall maintain a daily log (Form C-85) for both temporary and permanent pavement markings and markers. Entries in the log shall be made in ink, shall be legible, and the log shall be signed by the Contractor and delivered to the Engineer by the end of each workday.

Pavement line markings shall consist of stop lines, crosswalks, and solid or skip lines used for, but not limited to, dividing lanes, marking edges, channelizing, outlining and marking safety zones around objects, and forming islands and parking lot stalls.

1. **Crosswalks and stop lines** shall be installed using Type B, Class I or IV, markings.

TABLE VII-1
Pavement Markings

Type	Class	Name	Surface Temp. at Time of Application	Film Thickness (mils)	Pavement Surface	Application Limitations
A		Traffic paint	50°F+	15 ± 1 when wet	AC HCC	May be applied directly after paving operations
B	I	Thermoplastic Alkyd	50°F+	90 ± 5	AC	May be applied directly after paving operations
	I	Thermoplastic Hydrocarbon	50°F+	when set	AC	Do not apply less than 30 days after paving operations
	II	Polyester resin	50°F+	15 ± 1 when wet	HCC	Needs to be coned
	III	Epoxy resin	50°F+	20 ± 1 when wet	AC HCC	Pavement surface needs to be at least 1 day old
	IV	Plastic-backed preformed Tape	(Note 4)	60-90	AC HCC	Manufacturer's recommendations
	VI	Patterned preformed Tape	(Note 4)	20 min (Note 1) 65 min (Note 2)	AC HCC	Manufacturer's recommendations
D	I & II	Removable tape	(Note 4)	(Note 3)	AC HCC	Construction zone pavement marking
E		Removable black tape (Non-Reflective)	(Note 4)	(Note 3)	AC	Construction zone pavement marking for covering existing markings
F	I & II	Temporary markings	(Note 4)	40 max	AC HCC	Construction zone pavement marking

Note 1: Thinnest portion of the tape's cross section.

Note 2: Thickest portion of the tape's cross section.

Note 3: In the event the manufacturer's recommendation for film thickness is less than used when the material was tested by the National Transportation Product Evaluation Program or other Department-approved test facility, the minimum values used during installation shall conform to the test values indicated on the approved list for the specific marking.

Note 4: In accordance with manufacturer's recommendation.

2. **Solid lines or skip lines** shall be installed using Type A or Type B markings as specified.

Pavement message markings shall be installed using Type B, Class I, IV, or VI, markings and shall include, but not be limited to, school zone markings, railroad crossing markings, disabled parking symbols, elongated arrows, word messages, etc. The word SCHOOL shall be formed with characters that are 10 feet in height where permitted by the normal roadway width. School zone markings shall extend transversely across both lanes of two-lane roadways and across two or more approach lanes of roadways of three or more lanes. Disabled parking symbols shall be 41 inches in height, 36 inches in width, and shall use a 4-inch stroke width for the lines.

The Contractor shall protect the public from damage attributable to pavement marking operations. The Contractor shall be responsible for the complete preparation of the pavement surface, including, but not limited to, removing dust, dirt, loose particles, oily residues, curing compounds, concrete laitance, residues from eradication, and other foreign matter immediately prior to installing pavement markings. The pavement surface shall be dry at the time of installation when tested in accordance with VTM-94. The Contractor shall be responsible for providing the apparatus indicated in VTM-94 that are needed to perform the moisture test. Marking material shall not be applied within 24 hours following rain or other inclement weather.

Liquid markings shall be applied so as to prevent splattering and overspray and shall be protected from traffic until track free by the use of guarding or warning devices as necessary. If a vehicle crosses a marking and tracks it or if splattering or overspray occurs, the affected marking and resultant tracking shall be removed and new markings applied at the Contractor's expense.

Equipment shall also be thoroughly cleaned between changes in colors of materials.

Pavement markings shall have clean and well-defined edges without running or deformation; shall be uniform, free of waviness; shall be straight on tangent alignment; and shall be on a true arc on curved alignment. The widths of pavement markings shall not deviate more than 1/4 inch on tangent nor more than 1/2 inch on curves from the required width. The length of the gap and the length of the individual stripes that form skip lines shall not deviate more than two inches. The length of the gap and individual skip line shall be of such uniformity throughout the entire length of each that a normal striping machine will be able to repeat the pattern and superimpose additional striping upon the existing marking. Glass beads shall be applied at the rate specified herein and shall be evenly distributed over the entire surface of the marking. Beads shall be applied to the surface of liquid markings by a bead dispenser attached to the applicator that shall dispense beads simultaneously on and in the just-applied marking. The bead dispenser shall be equipped with a cut-off control synchronized with the cut off of the applied marking material so that the beads are applied totally to the completed line. Beads shall be applied while the liquid marking is still fluid. Approximately 70 percent of beads shall be buried in the marking, and the remaining 30 percent shall be 50 to 60 percent embedded in the surface. Beads installed on crosswalks and stop lines on roadways with curbs only (no gutter) may be hand applied for two feet at the end of each line next to the curb with 100 percent of the beads embedded 50 to 60 percent in the surface.

Markings found to be unacceptable shall be removed, and new markings applied at the Contractor's expense.

1. **Type A markings:** Paint may be applied to asphalt concrete and hydraulic cement concrete pavements. Paint shall not be applied over existing pavement markings of other materials unless the existing marking is 90 percent removed. Paint may be applied over existing paint markings.

Paint shall be applied with a line painting machine that is capable of hot spraying paint directly onto the pavement surface with a uniformity of feed through its nozzles for widths of 4 through 8 inches. The machine shall be capable of applying two pavement stripes, either solid or skip, at the same time when double line markings are required. Paint tanks on the equipment shall be equipped with a mechanical agitator and paint shall be thoroughly mixed and heated such that it will not track within 60 seconds after its application.

Non-truck mounted equipment shall be self-propelled and regulated to allow for calibration of the amount of material applied.

Glass beads shall be applied to the surface of the paint at the rate of 6 pounds per gallon of paint.

2. **Type B markings:** Equipment shall be capable of providing mixing, heating, and agitation of material. Material shall be uniformly heated throughout the system in accordance with the manufacturer's recommendations. Thermoplastic material shall be maintained in the heating kettle and applied to the road surface at a minimum temperature of 400 degrees F. Heating kettles shall be equipped with an automatic thermostatic control device. The Contractor shall furnish a properly calibrated infrared instrument for the purpose of measuring the actual temperature of molten thermoplastic material. Multi-component material shall be applied using internally injected guns for the mixing of catalyst and hardener.

Non-truck mounted equipment for application of thermoplastic material shall be of the screed extrude type with a screw drive or shall be self propelled and regulated to allow for calibration of the amount of material applied. Non-truck mounted equipment for application of polyester and epoxy resin material shall be self-propelled and regulated to allow for calibration of the amount of material applied.

- a. **Thermoplastic (Class I)** material shall be applied only on asphalt concrete pavements and shall be applied by screed extrude, ribbon gun, or spray equipment. Alkyd thermoplastic may be applied directly after the paving operations; however, hydrocarbon thermoplastic shall not be applied less than 30 days after the paving operations.

Alkyd and hydrocarbon materials shall not be mixed together. Equipment shall be thoroughly cleaned before types of material are changed.

Thermoplastic shall not be applied over existing pavement markings of other materials unless the existing marking is 90 percent removed. Thermoplastic may be applied over existing thermoplastic markings. For concrete bridge decks that occur in asphalt roadways, Type B, Class VI, tape shall be used.

Primer/adhesive shall be applied to asphalt concrete surfaces more than 2 years old and shall be from the same manufacturer as the thermoplastic.

Glass beads shall be applied to the surface of the marking at the rate of 7 pounds per 100 square feet.

- b. **Polyester resin (Class II)** material shall be applied only on hydraulic cement concrete pavements. Polyester resin shall not be applied over existing pavement markings of other materials unless the existing marking is 90 percent removed. Polyester resin may be applied over existing polyester resin markings.

Glass beads shall be applied to the surface at the rate of 8 pounds per gallon of material.

- c. **Epoxy resin (Class III)** material shall be applied only to asphalt concrete pavement more than 1 day old and hydraulic cement concrete pavement. Epoxy resin shall not be applied over existing pavement markings unless the existing marking is 90 percent removed.

Glass beads shall be applied by the gravity method to the surface at the rate of 25 pounds per gallon of material.

- d. **Plastic-backed preformed tape** shall be installed in accordance with the manufacturer's recommendations and as denoted herein. Tape may be applied to asphalt concrete and hydraulic cement concrete pavements. Tape may be installed immediately following the final rolling of the new asphalt concrete surface. Tape shall not be applied over existing pavement markings of other materials unless the existing marking is 90 percent removed.

Primer/adhesive shall be used for all installations except when tape is applied immediately following the final rolling of the new asphalt concrete surface and shall be from the same manufacturer as the tape.

Tape for pavement line markings shall be applied by an application cart as recommended by the manufacturer. Tape shall be tamped into place with a tamper cart with the weight as recommended by the manufacturer. The use of a vehicle to ride over the markings for tamping will not be permitted.

- (b) **Eradication:** Eradication of pavement markings for restriping when required shall be in accordance with the requirements of Section 512 except only 90 percent removal of the existing markings is required.

(c) **Pavement Markers:**

- 1. **Snow-plowable raised pavement markers** shall be installed by cutting two parallel grooves into the pavement at the depth and dimensions recommended by the manufacturer. Grooves shall be parallel to the adjacent pavement marking. Grooves shall be cut with saw blades having a diameter to match the curvature of the steel casting bottom and keels. Keel surfaces shall be free from scale, dirt, oil, grease, or any other contaminant that might reduce bonding.

Casting keels shall be bonded in the saw-cut grooves in the manner recommended by the manufacturer of the marker. The bonding material shall be from the Department's approved list or as recommended by the manufacturer of the marker. Noses of the casting shall be installed flush with the pavement surface. The installed height of the raised pavement marker shall be approximately 1/2 inch above the pavement surface. The ambient temperature at the time of installation of the snow-plowable raised pavement markers shall be at least 50 degrees F.

The top of reflectors shall be mounted flush with the top of the casting.

2. **Raised pavement markers** shall be bonded to the pavement surface in accordance with the manufacturer's recommendations. Bonding material shall be from the Department's approved list or as recommended by the manufacturer of the marker except that epoxy shall not be used on asphalt concrete pavements.

704.04—Measurement and Payment

Pavement line markings will be measured and paid for at the contract unit price per linear foot. This price shall include the pavement marking material, surface preparation, quality control tests, daily log, guarding devices, primer/adhesive, and glass beads.

Pavement message markings will be measured and paid for at the contract unit price per each per location. This price shall include the pavement marking material, surface preparation, quality control tests, daily log, guarding devices, primer/adhesive, and glass beads.

Pavement markers will be measured and paid for at the contract unit price per each. This price shall include prismatic retroreflectors, pavement cutting, adhesive, and castings.

Eradication of pavement markings will be measured and paid for in accordance with Section 512.

Payment will be made under:

Pay Item	Pay Unit
Pavement line marking (Type and/or class and width)	Linear foot
Pavement message marking (Message)	Each
Pavement marker (Type, []-way, and/or type pavement)	Each

SECTION 705—LIGHTING SYSTEMS

705.01—Description

This work shall consist of furnishing, installing, and testing proposed lighting systems and modifying or relocating existing systems in accordance with these specifications and in conformity to the lines and details shown on the plans or as established by the Engineer.

705.02—Materials

Photoelectric controls shall conform to the requirements of Section 238.

705.03—Procedures

The Contractor shall verify or locate the origin of the power source and verify voltage when modifying, removing, or relocating existing electrical systems and shall advise the Engineer at least 48 hours prior to the anticipated time of de-energizing any portion of the electrical system. Work shall be performed in accordance with the requirements of NEC and the standards of the local power company.

- (a) **Luminaires for Roadway Lighting:** Luminaires shall be installed in accordance with the manufacturer's recommendations. Luminaires shall be adjusted for maximum illumination and uniformity on the pavement or sidewalk as directed by the Engineer.
- (b) **Sign Luminaires:** Luminaires shall be shielded to eliminate glare or extraneous light on the roadway and shall provide a maximum-to-minimum uniformity ratio of 1:1 to 6:1 when installed. When tested at the center of a 10-foot-square test panel, the luminaire shall provide at least 30 average initial footcandles and a gradient (ratio of illumination on any two adjacent square feet of sign surface) of 2:1 or less.
- (c) **High-Mast Luminaire Assemblies:** Assemblies shall consist of a head frame assembly; luminaire ring; luminaire(s); winch assembly; a fail-safe mechanism to prevent accidental lowering of the luminaire ring; and incidentals necessary to raise, lower, supply, and control power to the luminaire ring. When an electric drill is required for raising and lowering the assembly, one drill shall be provided for each set of five high-mast luminaire assemblies or fraction thereof.
 1. **The lowering system** shall be compatible with the lighting pole and capable of raising and lowering a luminaire ring with eight luminaires.
 2. **The head frame assembly, luminaire ring, and canopy** shall be of a material that is resistant to weather, corrosion, and ultraviolet rays. The centering arms of the assembly shall provide stabilization of the luminaire ring during raising and lowering operations and shall maintain contact with the lighting pole for at least 2/3 of its length. A fail-safe latching mechanism shall be included in the head frame assembly that will remove the tension from the lowering cables when the luminaire ring is attached.
 3. **The winch assembly** shall include power cables of 600-volt, multi-conductor No. 10 (minimum), UL Type SO; lowering system cables of stranded stainless steel of sufficient strength and number to support and lower the luminaire ring and luminaires; and a 1/2-inch heavy-duty reversing electric drill or electric motor suitable for operation at the voltage shown on the plans. The winch assembly shall have a remote control that allows operation at least 15 feet from the lighting pole and shall be designed for lowering and raising the assembly by hand.
 4. **A junction box with a prewired terminal block** shall be furnished on the lowering ring with provisions for a photoelectric control. A circuit breaker shall be mounted in the hand hole area of the lighting pole. A watertight twist-lock power receptacle and

plug shall be provided for de-energizing the luminaire ring during raising and lowering operations and providing power for testing luminaires in the lowered position.

- (d) **Ballast:** The ballast shall be compatible with the luminaire and shall be a multivolt type capable of operating on 120-, 208-, 240-, and 277-volt electrical services. Ballasts for luminaires with lamp wattages of 150 watts or less may be nonregulating or regulating, having a power factor of more than 90 percent. Ballasts for luminaires with lamp wattages more than 150 watts shall be regulating. Nonregulating ballasts shall regulate lamp wattage within a line voltage variation of ± 5 percent. Regulating ballasts shall regulate lamp wattage within a line voltage variation of ± 10 percent. The Contractor shall certify that ballasts serving high-pressure sodium luminaires have a volt-watt characteristic curve that intersects the lamp voltage limit lines at points between the wattage limit lines throughout the full range of the lamp life and rated ballast line voltages. The basic and allowed variable volt-watt characteristic curves shall not intersect the wattage limit lines.

Ballasts and starting aids shall be capable of operating with the lamp in an open condition for 6 months without significant loss of ballast life and starting the lamp at temperatures as low as -20 degrees F.

- (e) **Control Centers:** Enclosures for control centers shall be NEMA 3R with provisions for locking. Electrical equipment shall be UL listed for the use indicated on the plans. Door openings for control center cabinets shall be at least 8 inches wider than the enclosed widest panelboard or other installed equipment whichever is wider. When multiple door control centers are provided, the door openings for each door shall be identical.
- (f) **Testing Electrical Components:** After energizing the lighting system, the Contractor shall demonstrate to the Engineer that electrical components are in working order. Faulty components shall be repaired or replaced by the Contractor at his expense.

The Contractor shall perform an operational test of the completed system under normal operating conditions for at least 3 consecutive days. Defective materials or improper installations shall be corrected by repairs or replaced by the Contractor at his expense.

- (g) **Electrical Equipment Containing Polychlorinated Biphenyl (PCB):** This work shall consist of determining, removing and disposing of electrical equipment containing PCB as a dielectric fluid or paste. Electrical equipment consists of, but is not limited to, capacitors, ballasts and transformers. Electrical equipment found in offset luminaires are excluded from the requirements of this section and need not be inspected for PCB contamination.
1. **Determination:** The Contractor shall determine if the electrical equipment that is to be removed contains PCB. This determination shall be made prior to removal of the equipment in accordance with the following:
 - a. Check the nameplate on the equipment to determine if any of the following trade names for PCB is indicated.

ALC	DK	Nepolin
Apirolio	Dykanol	Non-Flammable Liquid
Aroclor	EEC-18	No-Flamol
Aroclor B	Elemex	Phenoclor
Asbestol	Eucarel	Pydraul
ASK	Fenclor	Pyralene
Askarel	Hyvol	Pyranol
Capacitor 21	Iclor	Pyroclor
Chlorextol	Interteen	Saf-T-Kuhl
Chlorinol	Kanechlor	Santotherm
Clorinol	Kennechlor	Santotherm FR
Clorphen	Magyar	Santovac 1 and 2
Diaclor	MCS 1489	Therminol

- b. If these trade names are not indicated on the nameplate of the equipment and the equipment is not labeled as not containing PCB, the Contractor shall contact the equipment manufacturer for a determination of the existence of PCB in that equipment. The Contractor shall provide the information requested by the manufacturer, which will include at least the type, model, and serial number of the equipment. If the manufacturer indicates PCB does not exist in the equipment, the Contractor shall request that documentation in writing on the manufacturing company's letterhead stationery. The documentation shall include all information needed to verify the piece of equipment referenced.
 - c. If the procedures herein do not allow determination of the existence of PCB or if the manufacturer will not provide the necessary documentation in writing, the Contractor shall assume that PCB is contained within that equipment.
 - d. The Contractor shall notify the Engineer in writing of the determination of the existence of PCB in each piece of electrical equipment that could contain such. This documentation shall also include the name, representative's name, and telephone number for each company contacted to determine the existence of PCB. If the Contractor was able to obtain written confirmation from the manufacturer that PCB was not in a particular piece of equipment, the Contractor shall furnish the manufacturer's original letter to the Engineer.
2. **Removal and Disposal:** The Contractor shall follow the Environmental Protection Agency's guidelines and the Virginia Department of Environmental Quality's guidelines for the removal, transportation, disposal, and spills of PCB-laden materials. The Contractor shall provide the shipping manifest and all other correspondence concerning the removal and disposal of PCB-laden materials to the Engineer.

705.04—Measurement and Payment

Luminaires will be measured in units of each and will be paid for at the contract unit price per each. This price shall include the body, slipfitters, refractors, ballast, reflectors, sockets with lamps, conductor cables to the termini at the base, photoelectric controls and sockets, adjustment, and testing. Luminaires for sign lighting will not be measured for separate payment but shall be included in the price for overhead and bridge-mounted sign structures.

High-mast luminaire assemblies will be measured in units of each and will be paid for at the contract unit price per each. This price shall include the luminaire rings, lowering devices with head frames and assembly, winch assembly, electric raise/lower units, lowering cables, conductor cables to the termini at the base, luminaire units, lamps, photoelectric controls and sockets, testing, and adjustments.

Control centers will be measured in units of each and will be paid for at the contract unit price per each. This price shall include conduits, metal enclosures, ground rods, conductor cables, anchor bolts and templates, excavating, concrete, safety switches, panel boards, contactors, circuit breakers, photoelectric controls, terminal blocks, selector switches, testing, and adjustment.

Determination of electrical equipment containing PCB will not be measured for separate payment, and the cost thereof shall be included in the price bid for the removal of the electrical equipment.

Removal and disposal of electrical equipment containing PCB will be paid for in accordance with the requirements of Section 109.05 for extra work.

Payment will be made under:

Pay Item	Pay Unit
Luminaire (Size and type)	Each
High-mast luminaire assembly (Number of luminaires, size, and type)	Each
Control center (Standard and type)	Each

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TABLE OF EXTERNAL LINKS

Organization or Publication	Link
AASHTO Materials Reference Laboratory (AMRL)	http://www.amrl.net/
American Association of Highway and Transportation Officials (AASHTO)	http://www.aashto.org/
American Concrete Institute (ACI)	http://www.aci-int.org/
Americans with Disabilities Act (ADA)	http://www.usdoj.gov/crt/ada/adahom1.htm
American Institute of Steel Construction (AISC)	http://www.aisc.org/
American National Standards Institute (ANSI)	http://www.ansi.org/
American Nursery & Landscape Association (ANLA)	http://www.anla.org/
American Petroleum Institute (API)	http://www.api.org/Standards
American Society of Nondestructive Testing (ASNT)	http://www.asnt.org/
American Society for Testing and Materials (ASTM)	http://www.astm.org/
American Wood Preserver Association (AWPA)	http://www.awpa.com/
American Welding Society (AWS)	http://www.aws.org/
Code of Federal Regulations (CFR)	http://www.gpoaccess.gov/cfr/index.html
Concrete Reinforcing Steel Institute (CRSI)	http://www.crsi.org/
Erosion Control Technology Council (ECTC)	http://www.ectc.org/
Environmental Protection Agency (EPA)	http://www.epa.gov/
Federal Highway Administration (FHWA)	http://www.fhwa.dot.gov/
FHWA Standard Highway Signs	http://mutcd.fhwa.dot.gov/ser-shs_millennium_eng.htm
Federal Water Pollution Control Act (Section 404)	http://www.epa.gov/region5/water/pdf/ecwa_t4.pdf
Geosynthetic Accreditation Institute - Laboratory Accreditation Program (GAI-LAP)	http://www.geosynthetic-institute.org/gai/intro.html
Geosynthetic Institute (GSI)	http://www.geosynthetic-institute.org/
International Safety Equipment Association (ISEA)	http://www.safetyequipment.org/

Organization or Publication	Link
National Concrete Masonry Association (NCMA)	http://www.ncma.org/
National Cooperative Highway Research Program (NCHRP)	http://www.trb.org/CRP/NCHRP/NCHRP.asp
National Electrical Safety Code (NESC)	http://standards.ieee.org/nesc/
National Fire Protection Association (NFPA)	http://www.nfpa.org/index.asp
National Institute of Standards and Technology (NIST)	http://www.nist.gov/
National Pollutant Discharge Elimination System (NPDES) General Permit	http://cfpub.epa.gov/npdes/
National Ready Mixed Concrete Association (NRMCA)	http://www.nrmca.org/
National Transportation Product Evaluation Program (NTPEP)	http://www.ntpep.org/
Occupational Safety & Health Administration (OSHA)	http://www.osha.gov/
Prestressed Concrete Institute (PCI)	http://www.pci.org/intro.cfm
Resource Conservation and Recovery Act (RCRA)	http://www.epa.gov/region5/defs/html/rcra.htm
Society of Automotive Engineers SAE	http://www.sae.org/servlets/index
Society for Protective Coatings (SSPC)	http://www.sspc.org/standards/default.html
Underwriters Laboratories (UL)	http://www.ul.com/info/standard.htm
U.S. Army Corps of Engineers (USACE)	http://www.usace.army.mil/
U. S. Coast Guard (USCG)	http://www.uscg.mil/
U. S. Department of Agriculture (USDA)	http://www.usda.gov/wps/portal/usdahome
USDA Natural Resources Conservation Service (NRCS)	http://www.nrcs.usda.gov/
U. S. Department of Transportation USDOT	http://www.dot.gov/
Virginia Code of Laws	http://leg1.state.va.us/000/src.htm
Virginia Department of Agriculture	http://www.vdacs.virginia.gov
Virginia Department of Game & Inland Fisheries	http://www.dgif.state.va.us/
Virginia Department of Health	http://vdh.state.va.us/
Virginia State Corporation Commission Bureau of Insurance	http://scc.virginia.gov/division/boi